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Joint Agency Plan Aquatic Plant Management on Guntersville Reservoir

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by

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13. ABSTRACT *(Maximum 200 words)*

In response to the public, Congressmen Tom Bevill and Ronnie Flippo have directed the Tennessee Valley Authority (TVA) and the US Army Corps of Engineers to develop a 5-year comprehensive plan for managing problem aquatic plant populations in Guntersville Reservoir, located in northeastern Alabama. Principal Investigators from the TVA and the US Army Engineer Waterways Experiment Station are conducting a 5-year project following the rationale described in this plan. The Joint Agency Guntersville Project includes the enhancement of routine operational activities, demonstrations of current proven management technologies, and applied research investigations of value on both regional and national levels. In addition, the project includes the identification and quantification of aquatic plant effects on other water resources, as well as a public information program. To secure public involvement, the US Army Engineer District, Nashville, will direct the Master Planning and National Environmental Policy Act processes for resource management.

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Contents

Preface

The Joint Agency Guntersville Project is sponsored by the Tennessee Valley Authority (TVA) and the Headquarters, US Army Corps of Engineers (HQUSACE). The work reported herein is being conducted by the TVA, the US Army Engineer Waterways Experiment Station (WES), and the US Army Engineer District, Nashville (ORN).

The TVA Vector and Aquatic Plant Management Program, under the direction of Dr. Joseph C. Cooney, is serving as lead program for managing this project, with support from other organizations in River Basin Operations (RBO). Project funding is supported by Congressional appropriations to the TVA. The work is conducted under the management of Dr. Bill J. Bond, Vice President of RBO; Dr. Ralph H. Brooks, Manager of Water Resources; and Dr. Herbert C. Jones, Manager of the Aquatic Biology Department.

The WES work reported herein is conducted as part of the Corps of Engineers' Aquatic Plant Control Research Program (APCRP). The APCRP is sponsored by the HQUSACE and is assigned to the WES under the purview of the Environmental Laboratory (EL). Funding was provided under Department of the Army Appropriation 96X3122, Construction General. The APCRP is managed under the Environmental Resources Research and Assistance Programs (ERRAP), Mr. J. L. Decell, Manager. Mr. Robert C. Gunkel, Jr., is Assistant Manager, ERRAP, for the APCRP. Technical Monitor is Mr. James W. Wolcott, HQUSACE. Commander and Director of WES is COL Larry B. Fulton, EN. Technical Director is Dr. Robert W. Whalin.

Nashville District's involvement in the Joint Agency Guntersville Project includes participation in overall plan development and serving on the project management team. As part of the comprehensive project, TVA has transferred funding to the District for preparation of a Master Plan and NEPA document for aquatic plant management on Guntersville Reservoir. This work is performed within the Environmental Resources Branch, Engineering Division, under the direction of Mr. H. Joe Cathey. Point of contact for the project is Mr. C. Tom Swor. Commander of the Nashville District is COL James P. King.

The report was prepared by Mr. A. L. Bates, TVA; Mr. J. L. Decell, WES; and Mr. C. T. Swor, ORN.

Acknowledgment is made to Earl R. Burns, George P. Chambers, George R. DeVeny, Joseph P. Fehring, J. Ralph Jordan, Anne E. Lyon, Robert A. Marker, Wayne Poppe, Alan W. Voss, David H. Webb, and William B. Wrenn of the TVA; Robert C. Gunkel, Jr., John W. Barko, Alfred F. Cofrancesco, Kurt D. Getsinger, Jim E. Henderson, K. Jack Killgore, R. Michael Smart, and R. Michael Stewart of the WES; and Joe Morrison of the ORN, for their contributions in the preparation of workplans.

The report was edited by Ms. Jessica S. Ruff of the Information Technology Laboratory (ITL), WES. Ms. Betty Watson, ITL, designed and composed the layout.

Conversion Factors, Non-SI to SI (Metric) Units of Measurement

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
acres	4,046.873	square metres
feet	0.3048	meters
inches	2.54	centimeters
square miles	2.589998	square kilometers

1 Introduction

Site Description

Guntersville Reservoir is a 67,900-acre[1] impoundment of the Tennessee River in northeastern Alabama and southeastern Tennessee (Figure 1). It was constructed approximately 50 years ago for commercial navigation, flood control, and hydroelectric generation. Historically, the most significant aquatic plant infestations in the Tennessee Valley Authority (TVA) system have occurred in Guntersville Reservoir. This is primarily related to a limited annual water-level fluctuation of only 2.0 to 2.5 ft and an extensive littoral zone suited to colonization by submersed species, especially aggressive nonnative species (Figure 2).

Hydrilla (*Hydrilla verticillata* Royle), a nonnative species, is considered capable of growing at depths up to 20 ft in Guntersville, especially during years of relatively clear water. The area of shallow water (20 ft or less) suitable for dense colonization with submersed macrophytes in Guntersville Reservoir is projected to be about 30,000 acres. The availability of a large uncolonized vacant "niche" indicates that exotic species have not yet exploited all available habitats and, in the absence of control measures, can be expected to continually expand until all the niches are filled when conditions are favorable.

The successional potential exhibited by introduced invasive species also exists for similar habitats in other TVA reservoirs as well as within numerous US Army Corps of Engineers (USACE) projects in the region and throughout much of the Nation. The assemblage and abundance of exotic species, such as hydrilla and Eurasian watermilfoil (*Myriophyllum spicatum* L.) currently found within the Tennessee-Tombigbee Waterway, serve as an indication to resource managers that the shallow impoundments along this extensive and important waterway could also be colonized. Countless small private lakes and ponds throughout the region also provide potential habitat for these species if propagules should be introduced

[1] A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page vii.

Figure 1. Guntersville Reservoir is a 52-year-old mainstream reservoir impounding 67,900 acres in Jackson and Marshall Counties in northeastern Alabama and Marion County in southeastern Tennessee

Figure 2. Eurasian watermilfoil colonizes extensive shallow littoral zones throughout mainstream TVA reservoirs, such as this site at Sublett Ferry, Guntersville Reservoir

and, once infested, could provide a continuing source of plants for repopulation of lakes and reservoirs.

History

As a result of the 4-year drought from 1984 to 1988, excellent conditions for aquatic plant growth existed in the Midsouth. During this period, more than 46,000 acres of shallow water was colonized by submersed aquatic plants in 11 reservoirs of the Tennessee River system, causing the overall distribution of aquatic plants to double (Figure 3). Aquatic plant colonization was especially rapid on Guntersville Reservoir, where about one third the surface area supported submersed aquatics and a major noxious weed, hydrilla, expanded to about 2,900 acres.

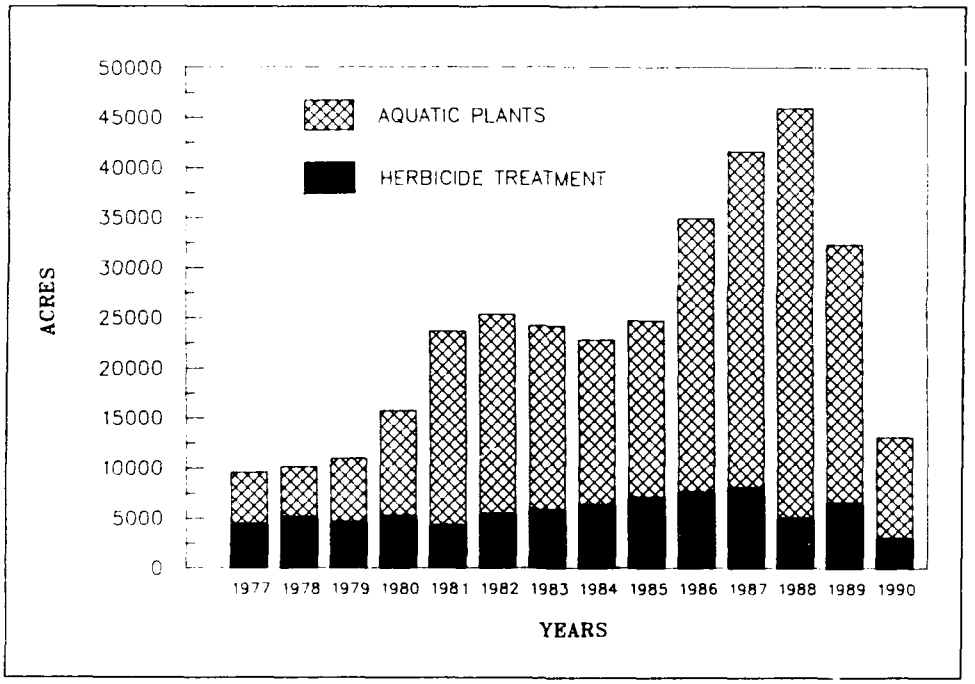


Figure 3. Area coverage of submersed aquatic plants on nine TVA mainstream reservoirs and two tributary reservoirs (as determined by site surveys), along with herbicide treatments for the period 1977-90

More recently, the heavy midsummer rains experienced in 1989 and in the spring of 1990 caused reservoir conditions that were less favorable for submersed plant growth. As a response to the conditions created by the weather, the areal coverage of aquatic plants declined to about 32,000 acres throughout the Tennessee Valley in 1989 and to about 14,200 acres in Guntersville Reservoir (Figure 4). The spring rains and subsequent addition of turbid water in the reservoir in 1990 further inhibited the growth of submersed aquatic plants within the reservoir system. In addition

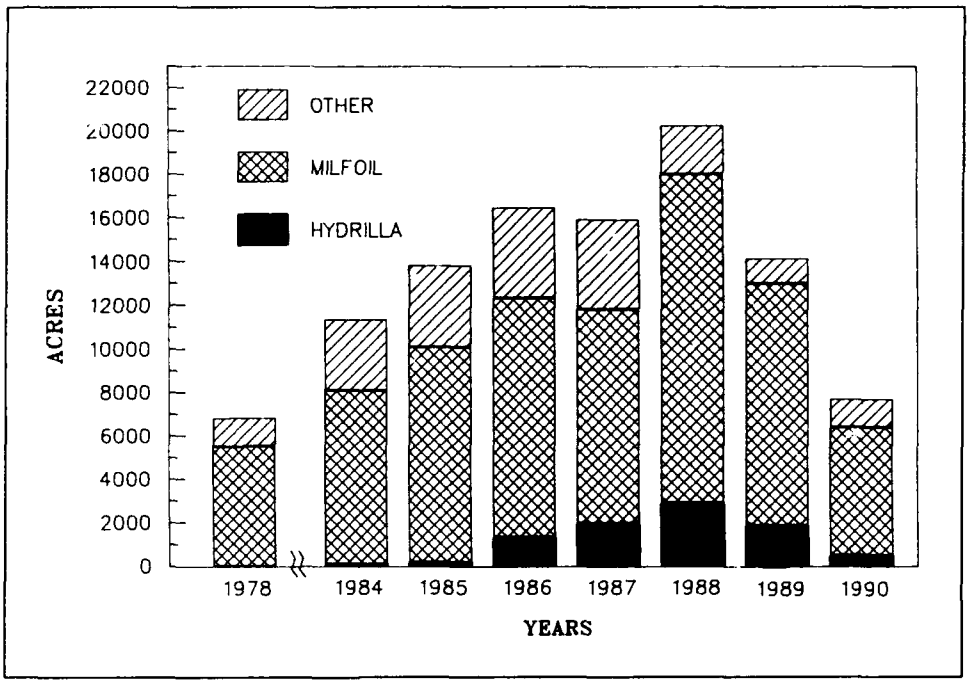


Figure 4. Area coverage of submersed aquatic plants for Guntersville Reservoir for 1978, the period 1984-90

to the apparent reduction in aquatic vegetation in Guntersville caused by the scouring action of high flows, flood control operations during this period dispersed aquatic plant fragments over spillways to other mainstream reservoirs throughout the downstream TVA system. These fragments are expected to root and establish new colonies of plants in previously uncolonized areas.

The significant variations in abundance of aquatic vegetation experienced in the Tennessee Valley reflect the rapidity of major changes that can be brought about by weather conditions, especially abundance and timing of rainfall during critical growth periods. Obviously, the inability to accurately predict long-term weather conditions precludes projections of changes in aquatic vegetation populations. However, the 4 years of extreme record-drought conditions and the resulting effects on the growth rate and abundance of submersed plants have demonstrated the rapid response capabilities of nonnative plant species to expand under favorable growth conditions.

It is important to point out that aquatic plants perform many beneficial functions in the aquatic ecosystem as well as creating conflicts. Plants provide substrate for a diverse assemblage of small aquatic organisms, cover and nursery areas for certain fish, and food and resting areas for waterfowl and wading birds (Figure 5). They produce oxygen through photosynthesis in the presence of sunlight, reduce turbidity, and stabilize the hydrosoil. It is when they are present in excessive amounts, in certain reservoir areas, that they cause conflicts with various valued reservoir uses,

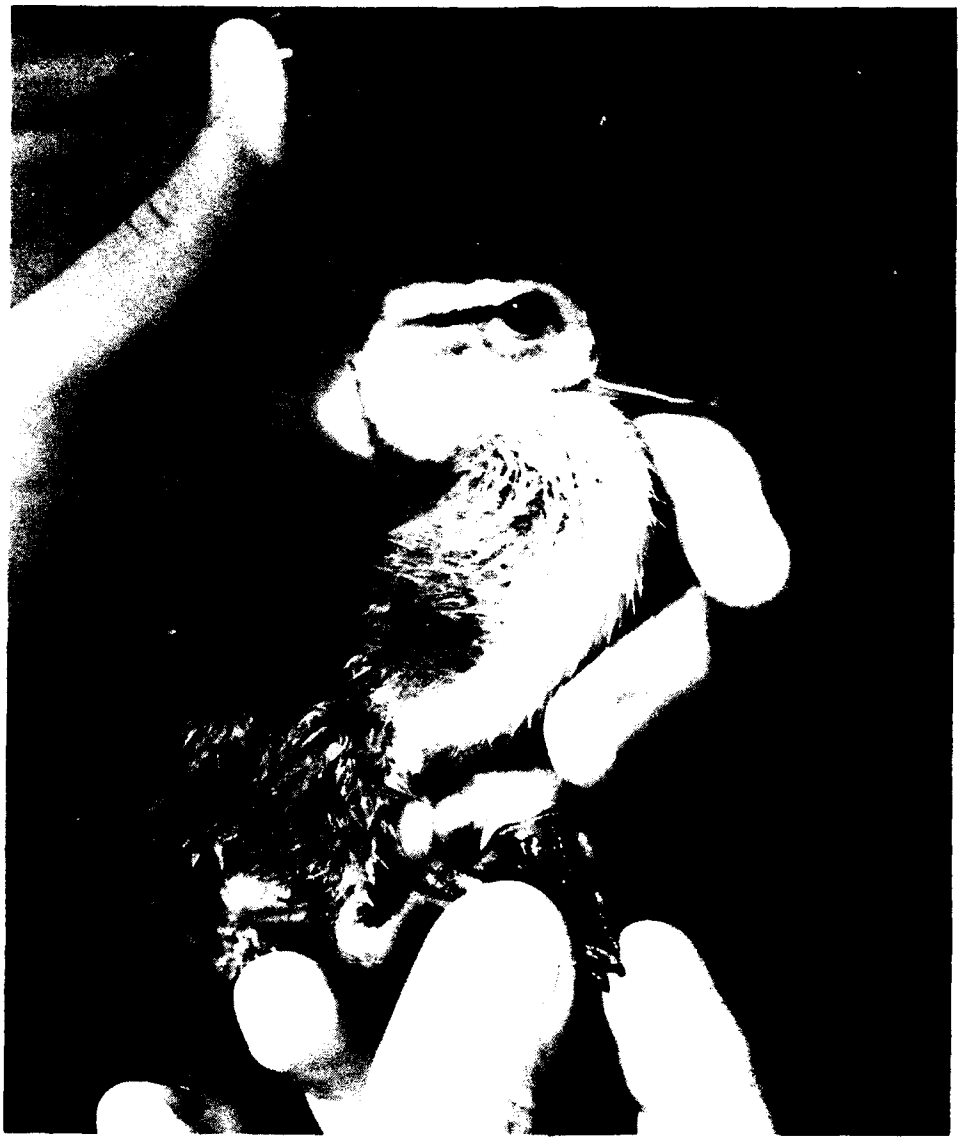


Figure 5. Aquatic plants provide essential food and cover for resident and seasonal waterfowl, including favorable habitat conditions for juvenile wood ducks

thus becoming a problem (Figure 6). In this situation, the excessive plants restrict access to docks and launching areas; interfere with recreational activities, e.g., swimming, fishing, and boating; foul shorelines with unsightly plant debris; increase nuisance mosquito populations, which increases the potential for disease transmission; "consume" dissolved oxygen during decay and respiration; reduce water storage capacity; degrade water quality; and clog water intakes. Both beneficial aspects and use conflicts exist at Guntersville Reservoir as a result of the extensive colonizations and increasing diversity of submersed aquatic plants.

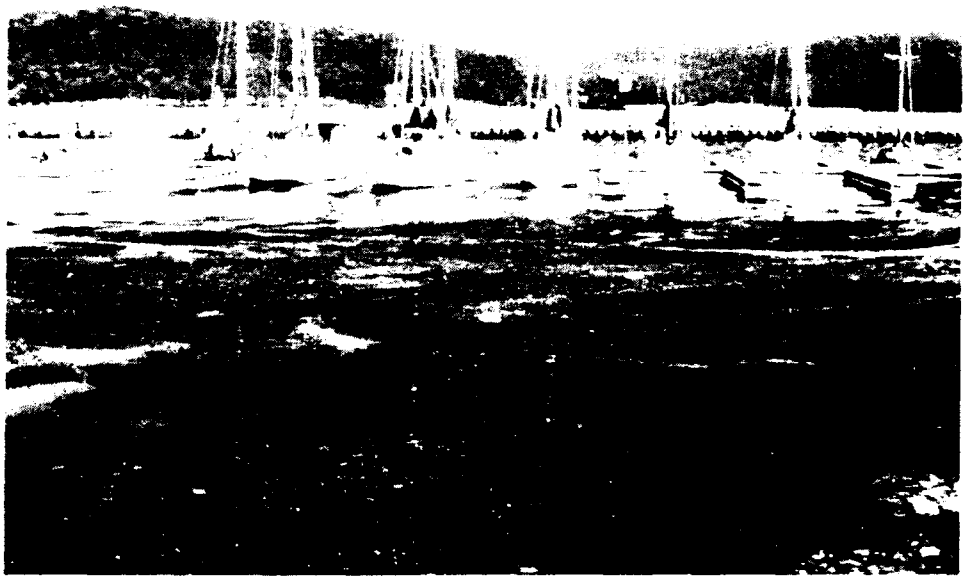


Figure 6. Typical infestation of dense hydrilla in a deep-water marina site before herbicide treatment—Guntersville Reservoir

Three introduced species, Eurasian watermilfoil, spiny-leaf naiad (*Najas minor* All.), and hydrilla, are now the principal plants of concern in TVA reservoirs. In the TVA system, nine mainstream reservoirs and two tributary reservoirs (total surface area, 475,000 acres) support populations of aquatic plants (Figure 7). Together, Eurasian watermilfoil, spiny-leaf naiad, and hydrilla accounted for about 80 percent of the 1988 acreage (46,000 acres) of aquatic vegetation in these 11 reservoirs.

Eurasian watermilfoil

Following planting of this species by a marina operator in the 1950s in Watts Bar Reservoir in east Tennessee, the proliferation of watermilfoil was rapid and widespread throughout the TVA mainstream reservoirs. With an abundance of ideal shallow-water habitat coupled with ample nutrients to sustain it, watermilfoil rapidly filled a vacant niche and remains the dominant submersed macrophyte after 30 years. This perennial macrophyte reaches greatest densities and sustains persistent populations throughout the year in reservoirs where annual fluctuations of water level are minimal.

Guntersville Reservoir, which has a minimal fluctuation from top summer pool to low winter pool elevations, is considered to have extensive suitable habitat conditions for watermilfoil establishment and growth when compared to the other mainstream reservoirs. Tributary reservoirs, with their large amplitude of fluctuation, are unsuited for survival of watermilfoil

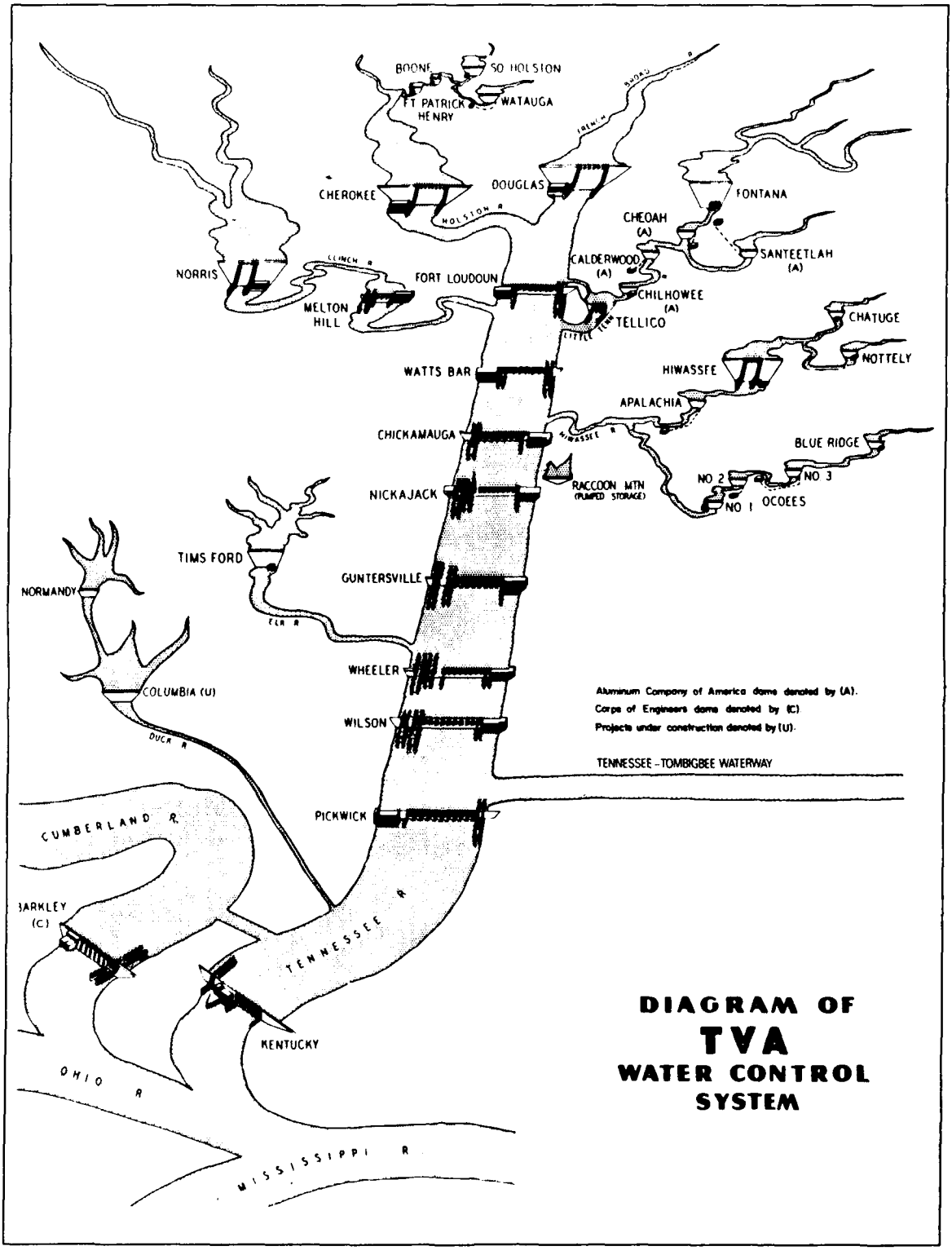


Figure 7. Nine mainstream reservoirs and numerous tributary reservoirs impound about 625,000 acres at full pool. The water control system manipulates drainage from 41,000 square miles

and other perennial submersed plants because of the exposure and destruction of propagules. Further, because watermilfoil is physiologically adapted for colonization of small lakes, ponds, streams, and rivers, it poses a threat to watercourses throughout the region, especially since spreading by boaters is so common.

Spiny-leaf naiad

Spiny-leaf naiad, by virtue of its annual growth cycle that includes regrowth from seed, can tolerate exposure to freezing and drying in the seed stage. This Old World plant is adapted to fluctuating water levels and receives only limited competition from other submersed species in the seasonally flooded drawdown zone of reservoirs.

Since its discovery in the Tennessee Valley in 1938, spiny-leaf naiad has been found throughout the Tennessee Valley in habitats ranging from small farm ponds to large reservoirs. The abundance of seed produced by this species and probable long-term seed viability aid in the rapid recolonization of aquatic sites following drawdowns or other control measures. Suitable growing conditions, especially clear water in the early spring growth phase, have also been demonstrated to be critical for development of maximum plant biomass. Abundant naiad biomass during the summer months causes interference with other reservoir uses, such as swimming and boating, although the problems are not as severe as those experienced with watermilfoil and hydrilla.

Hydrilla

Hydrilla causes major problems in several states and is one of the most noxious aquatic plants in North America (Figure 8). Hydrilla was discovered in Guntersville Reservoir in 1982. By 1988 it had colonized 2,900 acres and was scattered over 45 river miles. Hydrilla was reduced to about 1,900 acres in 1989, primarily due to hydrologic conditions that removed top growth; however, its distribution continued to expand. In areas where hydrilla has temporarily declined because of growing conditions, regrowth is expected to originate from tubers remaining in the substrate from former colonies or from redistribution of plant fragments. Expansion of its distribution is expected with the return of normal growing conditions within the reservoir. Rooted colonies of hydrilla have now been found in Wilson, Wheeler, Guntersville, Nickajack, and Chickamauga Reservoirs.

If not suppressed, hydrilla is expected to become the dominant submersed aquatic plant in the Tennessee River system within the next decade. It has the potential to completely replace most native colonies of submersed plants in Guntersville, and will likely outcompete the other two introduced species, Eurasian watermilfoil and spiny-leaf naiad, in many areas.

Figure 8. Hydrilla was first detected in Guntersville Reservoir in 1982, but has since spread to four other mainstream reservoirs

Project Background

Stimulated by the interest of the local constituency in recent aquatic plant growth in Guntersville Reservoir and associated concerns, Congressmen Tom Bevill and Ronnie Flippo reviewed the situation in 1988. The TVA and the USACE were directed to develop a 5-year comprehensive plan for reducing excessive plant populations to manageable nonproblem levels in Guntersville Reservoir.

The aquatic plant management plan consists of three major components: (1) operational enhancement, which includes expansion of routine operational control measures as part of TVA's stewardship responsibilities; (2) demonstrations of current proven technologies that must be tailored to local conditions at a large scale and evaluated for effectiveness, economy, and environmental impact before becoming operational; and (3) applied research, which requires additional data in the local region before being integrated with the large-scale test demonstrations or into the operational

programs. A substantial part of the plan includes provisions for identifying and quantifying the effects of aquatic vegetation on other water resource uses, such as recreation, economic development, and water supply (for both industrial and public uses).

Purpose and Scope

The overall purposes of the project are to (1) identify the conflicts that exist with multipurpose reservoir uses; (2) implement proven management techniques for reducing current aquatic plant infestations causing the conflicts, thereby restoring beneficial uses; (3) develop more effective aquatic plant control technologies directly applicable to Guntersville, as well as to other TVA and USACE reservoirs throughout the region and the Nation; and (4) optimize benefits provided by aquatic plants where use conflicts are minimal.

Approach

Many user groups have widely divergent opinions regarding the extent to which aquatic vegetation should be controlled. For example, some sport fishermen (Figure 9) and waterfowl hunters want very limited or no control of aquatic vegetation. Conversely, water contact recreationists, boaters, bank fishermen, commercial interests, park managers, and shoreline property owners (Figure 10) usually want the maximum control possible, even eradication. There are often uncompromising differences of opinion among these special-interest groups over the degree of aquatic plant management desired for various resource uses.

Throughout this project, efforts will be made to accommodate as many uses as possible by varying the type and level of aquatic plant management to fit the user patterns in each area of Guntersville Reservoir without compromising the biological integrity of the reservoir (Figure 11). This will ultimately require better definition of the desired amount and distribution of aquatic plant colonies necessary to accommodate the varied uses. Certain compromises among the user groups, as well as between user groups and reservoir managers, will be necessary. Overall, this plan makes provisions for

- Initiating and continuing a balanced, integrated aquatic plant control effort, so that further consumptive and nonconsumptive conflicts with water use are minimal.

- Coordinating demonstration and study plans with the general public.

Figure 9. Guntersville Reservoir is rated as one of the top sport-fishing reservoirs in the South, with anglers enjoying great success in catching largemouth bass

Figure 10. Seasonal and permanent shoreline property owners encounter dense mats of aquatic plants on Guntersville Reservoir during the summer months

Figure 11. Water contact sports, such as boating, swimming, and skiing, are eliminated when excessive aquatic plants colonize shallow littoral zones

- Incorporating improved control technologies and management strategies into the operational programs, as results from the applied research and demonstrations become available.

Findings from this project are expected to have wide applicability to reservoir projects throughout the Nation; thus, technology transfer is a major element of this joint project.

Objectives

The TVA's aquatic plant management objective for Guntersville and other infested reservoirs is neither to eradicate aquatic vegetation, which would eliminate the benefits it can provide, nor to allow excessive proliferation, which would preclude full utilization of the multipurpose reservoir system.

The **overall** objective of the Joint Agency Guntersville Project (JAGP) is to develop more efficient and effective methods of managing aquatic vegetation in order to maintain a balance between vegetated and open-water areas compatible with the various uses and to implement these methods in an environmentally sound manner.

Specific objectives of the Guntersville Reservoir plan are to

- Reduce aquatic plant infestations below levels that interfere with multipurpose reservoir uses by 1993.
- Manage remaining vegetation to maintain fisheries, waterfowl, and wildlife habitat, while accommodating other uses of this multipurpose impoundment.
- Use Guntersville Reservoir as a regional and national demonstration site for emerging aquatic plant management technologies.
- Develop and incorporate economic evaluation techniques into the implementation and assessment of future aquatic plant control programs.
- Develop a measure of the value of aquatic plant control and assess the impact of aquatic plants on reservoir recreation use.

Agency Responsibilities

All current operational aquatic plant control activities will be continued by TVA as a part of its stewardship responsibilities. To ensure that the existing level of maintenance control now achieved in most areas of Guntersville Reservoir is not jeopardized, the current operational control program will continue to integrate chemical control with drawdowns within the mainstream reservoirs. The TVA operational program remains flexible to the degree that adjustments can and will be made any time a new or improved control technology becomes available. Each major agency involved in this joint project and other agencies with similar programs will ultimately benefit from this approach.

Tennessee Valley Authority

The TVA was designated as the lead agency, with overall responsibility for planning, budgeting, and directing the joint project. Other responsibilities include National Environmental Policy Act (NEPA) compliance, demonstrations, field monitoring support, public information meetings, information-education programs, and physical facilities support. TVA has a Congressional mandate to manage the Tennessee River and its tributaries; inherent in this stewardship responsibility has been the management of the water resources. Aquatic vegetation and other factors that influence the utility of the water resource are identified and managed for the public welfare. Expertise in the management of aquatic vegetation was acquired soon after the formation of TVA, because aquatic vegetation

was recognized early as a major factor affecting reservoir use as well as mosquito production. The natural resources database and expertise developed over the 50-year period is extensive and provides a sound background for directing the JAGP.

Waterways Experiment Station

The US Army Engineer Waterways Experiment Station (WES) is the Corps of Engineers' largest research facility. As part of its responsibilities, WES is mandated to conduct a national Aquatic Plant Control Research Program (APCRP). Technology developed through this program is transferred to USACE projects, and in turn to the States through operational programs. In addition, technology is provided to other interested Federal agencies or groups. Given the facilities and national technical expertise available, the WES was designated to conduct the applied research portion of the project and to participate with TVA in certain demonstrations. In addition, WES is conducting related research efforts through the APCRP. The WES also provides the project and TVA with necessary technical support for the control technologies.

Nashville District

The US Army Engineer District, Nashville, was designated to participate in the project by virtue of (1) its proximity to and long-time operational relationship with the TVA system (the TVA system is included within the District's Civil Works boundaries, and TVA's Kentucky Reservoir connects with the Corps' Barkley Reservoir via open canal) (Figures 7 and 12); (2) the emerging watermilfoil colonization on the Cumberland River Reservoir system; and (3) Nashville District's technical expertise in the Master Planning and NEPA processes for resource management. The District will also serve in a liaison capacity for WES activities and will provide the necessary administrative support and coordination to TVA and WES for project implementation.

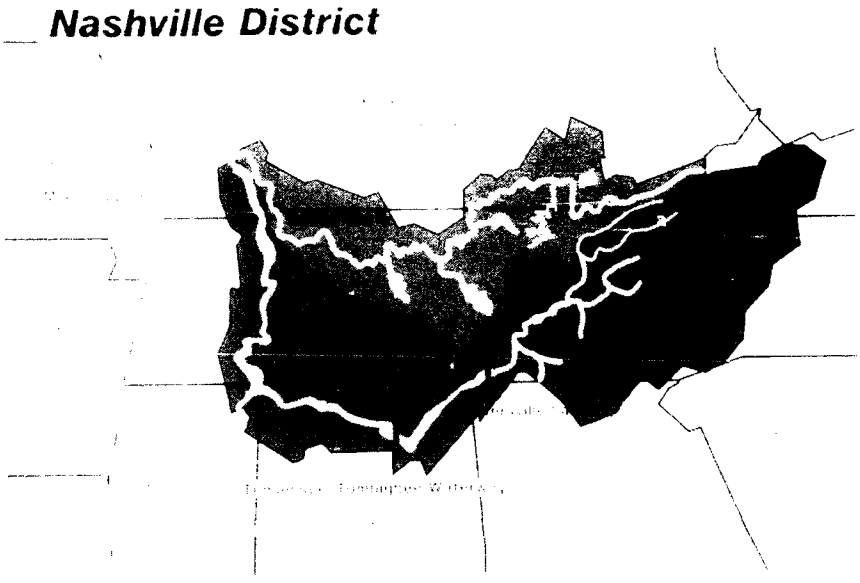


Figure 12. The Tennessee and Cumberland Rivers connect by barge canal which joins Kentucky and Barkley Reservoirs at the downstream *end of the watersheds*

2 Project Descriptions

Planning and Review Process

The Nashville District will direct the application of the Master Planning process commonly used by the USACE for natural resource management. Resource management guidelines will be prepared that recommend aquatic plant management strategies based on input from the various user/interest groups. A contractor has been selected to obtain public input; assemble historical, economic, and biological information about Guntersville Reservoir; and coordinate with TVA to prepare a plan that describes levels of control in various areas of the reservoir and evaluates the environmental effects of alternative control levels.

Possible control options, based on quantity and distribution of aquatic plants, will be developed through public involvement workshops and a review of existing information. The ultimate product will be a long-range, flexible aquatic plant management plan developed specifically for Guntersville Reservoir using the Master Planning process.

More detail is presented in Appendix A, in the summary workplans titled Project Administration and Planning and Aquatic Plant Management Master Plan.

Information and Education

An information and education program will be developed and implemented for the purpose of communicating the objectives and results of the JAGP to the public. Both printed information and audio-visual material will be utilized in this effort. This program will extend throughout the 5 years of the project, with major emphasis during the first year of project implementation. It is expected that numerous technical reports and publications will arise from these investigations; however, these will be generated within each specific technical project area, and will be made available through respective agency distributions rather than through the Information and Education component of the JAGP. Findings of technical

studies will be summarized in nontechnical formats for distribution to the public.

A more detailed description of this project area is presented in Appendix B, in the summary workplan titled Information and Education Programs.

Economic/Recreation Evaluations

Economic evaluations

No method is currently available for comparing the costs and benefits of alternative technologies and/or strategies for aquatic plant management programs. This investigation will involve the development of economic valuation techniques for the implementation and assessment of aquatic plant control programs. For example, impacts of aquatic plants on land use changes and recreation are generally acknowledged, but not well documented. Results from this study can have major implications for guiding aquatic plant management measures, not only in the TVA reservoir system but for USACE projects throughout the Nation.

Land value evaluations

Empirical data from real estate agents, homeowners, and shore-based businesses indicate that shoreline property "value" decreases as aquatic plants increase. However, determinations of actual or projected value changes have not been studied using current sampling and assessment techniques. This evaluation will more accurately quantify the changes in property value associated with presence or absence of aquatic plants and thus will provide essential data for cost-benefit analysis. Results from local assessments will be more applicable to the immediate region because of the geographical variability of property value outside the area; however, methods of determination will have application throughout the Nation.

Recreation evaluations

Measurement of the specific value of aquatic plant management to reservoir recreation use can provide needed guidance for conducting programs within TVA reservoirs and USACE reservoirs throughout the Nation. Determinations will be made of the current use characteristics, public perceptions of current conditions, preferred levels of vegetation and control techniques, effects of vegetation on recreation users, willingness to pay for various levels of control, and economic impact of recreational use in the local region. This information will help to quantify recreational impacts, thus providing a basis for better cost-benefit analysis.

More details of the economic/recreation portion of the project are included in Appendix C, in the summary work plans titled Economic Valuation of Aquatic Plant Control, Land Value - Economic Evaluations, and Recreation - Economic Evaluations.

Database Development and Environmental Evaluations

Because of the nature and magnitude of this project and its potential to exert an influence on the aquatic resources of Guntersville Reservoir, as well as the users of these resources, a major component of this project is directed at evaluating the effects of the project on all aspects of the reservoir and its users. These evaluations will be conducted to document the responses of fisheries, plants, water quality, waterfowl and wading birds, and threatened and endangered species to aquatic plant management efforts in Guntersville. To provide the common geographical database needed for a project of this magnitude and complexity, a corrected base map for Guntersville Reservoir will be prepared for various data entries. This and other database development activities will consider and be compatible with TVA's other data needs, such as future requirements for maps used for Land Management Plans.

Field support facilities, located at TVA's Murphy Hill site, include an office area, equipment storage sheds, and a boat-launch ramp suitable for access to the reservoir (Figure 13).

More detail concerning databases and environmental evaluations is presented in Appendix D, in the summary work plans titled Database Development and Implementation, Aquatic Macrophyte Evaluations, Monitoring Water Quality Impacts, Fisheries Evaluations, Waterfowl and Wetlands Wildlife and Threatened and Endangered Species Evaluations, and Phytoplankton Evaluations.

Operational Enhancements

Mechanical control

To quickly restore water uses in high-use areas, and to evaluate the overall operational efficiency of a mechanical harvester in Guntersville Reservoir, a mechanical harvester has been obtained through a lease-agreement contract (Figure 14). In addition to providing onsite operational control data, the harvester will be used to obtain biomass data, in support of the macrophyte sampling program, and to cut varying patterns of boat lanes. These boat lanes are being evaluated for their utility for boat access and to assess

Figure 13. Two large ponds located on TVA's Murphy Hill industrial site serve as field test sites for plant competition and biocontrol studies

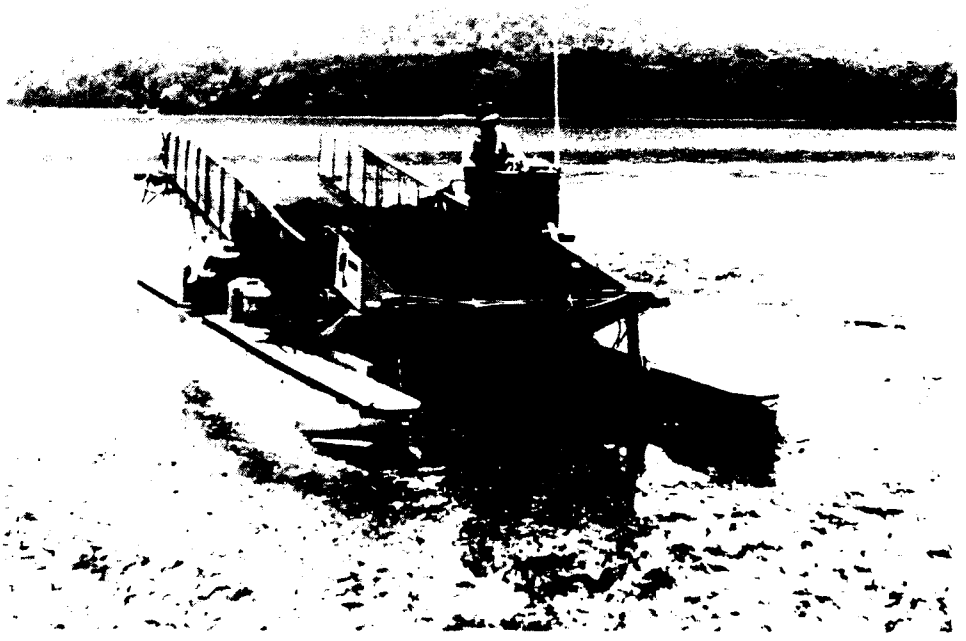


Figure 14. A leased harvester with a 5-foot-wide cut is used to develop operational control data, and provides support for plant biomass determinations and boat lane studies

the resulting vegetation's "edge effect" for fisheries benefits (Figure 15). Biomass data, including operational efficiency data, will be used to further validate the WES HARVEST mathematical model and to supplement aquatic plant competition studies.

Figure 15. Various configurations of boat lanes were cut with a harvester through dense hydrilla colonies to evaluate fish use, access by anglers, and water exchange characteristics

The proposal was made to add a second harvester to the project through the lease agreement in fiscal year (FY) 1991. However, this addition may be delayed, since TVA has acquired a skimmer/harvester for clearing debris at hydroelectric facilities. A harvest cutterhead has been secured for the skimmer unit, and field evaluations are planned in 1991.

Chemical control

Herbicide control is presently the most commonly used control technology available to the aquatic plant manager (Figure 16). New herbicides are rarely developed specifically for aquatic plant control because of the low-volume sales market potential. Thus, reliance must be placed on the six currently available US Environmental Protection Agency-registered aquatic herbicides. Improvements in delivery systems, timing of applications, and site conditions are important considerations for more efficient use (i.e., accomplishing control objectives with less chemical application). This portion of the project will address these needs, as well as the development of scientific data on residue dynamics for use in support of continued operational use of herbicides, provided the data support no evidence of adverse effect to man or the environment.

Figure 16. Airboats equipped with spray booms disperse aquatic herbicides subsurface within priority treatment sites

A contractor has been selected to conduct a comprehensive study of dissipation rates of herbicides in soil, water, fish, molluscs, and plants, in addition to determining acute effects on biological organisms. Municipal

water supplies will be monitored monthly during periods of herbicide use, and special sequential residue monitoring studies will be conducted.

New herbicide formulations such as granular endothall and bensulfuron methyl (Mariner) will be field tested for efficacy. Inert, concentrated dyes will be applied alone and/or in combination with herbicides, and will be monitored following application for comparison with herbicide residue analyses. This will aid the current and future operational control program by developing a more efficient, reliable way to determine rates of herbicide residue dissipation.

Details for the Operational Enhancement area of the project are presented in Appendix E, in the summary work plans titled Mechanical Control - Aquatic Plant Harvester and Chemical Control.

Demonstrations

Grass carp stocking

During the period April-July 1990, approximately 100,000 sterile triploid grass carp were stocked at 23 locations around Guntersville Reservoir to serve as a large-scale test demonstration (Figure 17). The primary objective is to significantly reduce the biomass of hydrilla and stop its spread while achieving limited control of other submersed species. Based on computer modeling and input from public sources as well as state fisheries programs, a conservative (i.e., low) stocking rate was selected.

As proposed in the final Environmental Assessment, entitled "Demonstration of Use of Grass Carp in Management of Aquatic Plants in Guntersville Reservoir," 100,000 grass carp were stocked and are being evaluated through the monitoring program described in the Database Development and Environmental Evaluations section. Additional stockings, if needed, would not be made until FY 1992, after two growing season assessments have been completed. A relatively low initial stocking rate (5 to 7 fish per acre of submersed vegetation) was used, and future stockings will be dependent upon the amount of remaining aquatic plant biomass.

As discussed in the Database Development and Environmental Evaluations section, a detailed monitoring program has been implemented to assess changes in the major biological components of the aquatic ecosystem, along with water quality changes. These components include fisheries evaluations, waterfowl and wetlands wildlife assessments, threatened and endangered species studies, effects on aquatic macrophytes, and water chemical determinations. Details of these studies are presented in Appendix D.

Figure 17. Sterile triploid grass carp were stocked in Guntersville Reservoir, April-July 1990, as a large-scale demonstration evaluation

Simulation modeling

Simulation models applicable to aquatic plant populations in Guntersville Reservoir will be refined and linked into a personal computer software package. An environmental database will be developed for Guntersville Reservoir using acquired and existing TVA data. Three simulation models developed by the WES—HARVEST (mechanical harvesting), STOCK (grass carp), and FATE (herbicides)—will be used for planning and evaluation of the various treatment methods available for aquatic plant control. Simulation modeling will be conducted by WES, incorporating biological data from various databases.

Benthic barrier

Recently improved benthic barriers have been installed on the reservoir bottom at several locations in Guntersville Reservoir to provide quantitative data relating to the effectiveness and environmental impacts of barriers (Figure 18). Additional environmental data are needed to quantify changes in the chemistry and biology underlying the barriers. The investigations will also determine possible alterations in sediment chemistry that may influence aquatic plant regrowth at treated sites once the barrier is removed.

Figure 18. Benthic barriers have been anchored to the substrate in shallow littoral zones of Guntersville Reservoir to keep submersed vegetation from rooting in the substrate or to shade existing submersed species

Details of the demonstration portion of the project are provided in Appendix F, in the summary work plans titled Grass Carp Stocking, Simulation Modeling, White Amur Model Predictions and Monitoring, Creation of Boat Lanes for Fishery Enhancement, and Application of Benthic Barrier Technology.

Applied Research

Biological control

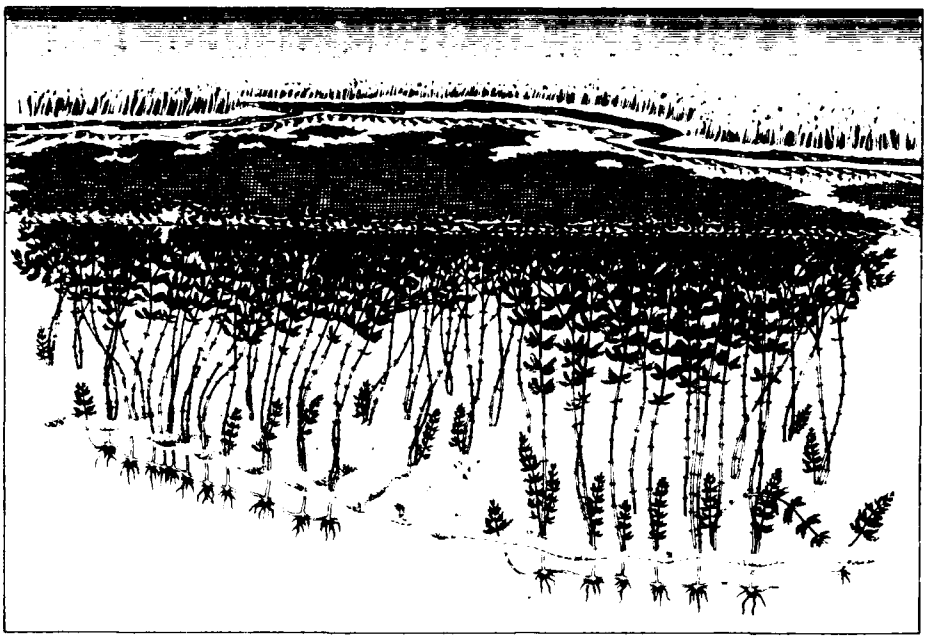
Biological control of problem aquatic plants using insects and fungal pathogens has the potential to provide long-term, cost-effective, specific control of problem plants without affecting desirable native plants. These applied investigations will involve the release and evaluation of two promising biocontrol agents for the control of watermilfoil and hydrilla. Two species of insects (*Hydrellia* sp.) that feed **only** on hydrilla (Figure 19) will be evaluated, along with a fungal pathogen (*Mycoleptodiscus terrestris*) that affects **only** watermilfoil. Initial field testing for both organisms will involve studies in ponds at the Murphy Hill site along with limited studies in isolated hydrilla colonies within Guntersville Reservoir.

Figure 19. A host-specific hydrilla fly (*Hydrellia* sp.) deposits eggs on emerging hydrilla plants; the eggs hatch and the leaf-mining larvae "mine" the leaves. A control hydrilla plant is located on the left, and a damaged plant on the right

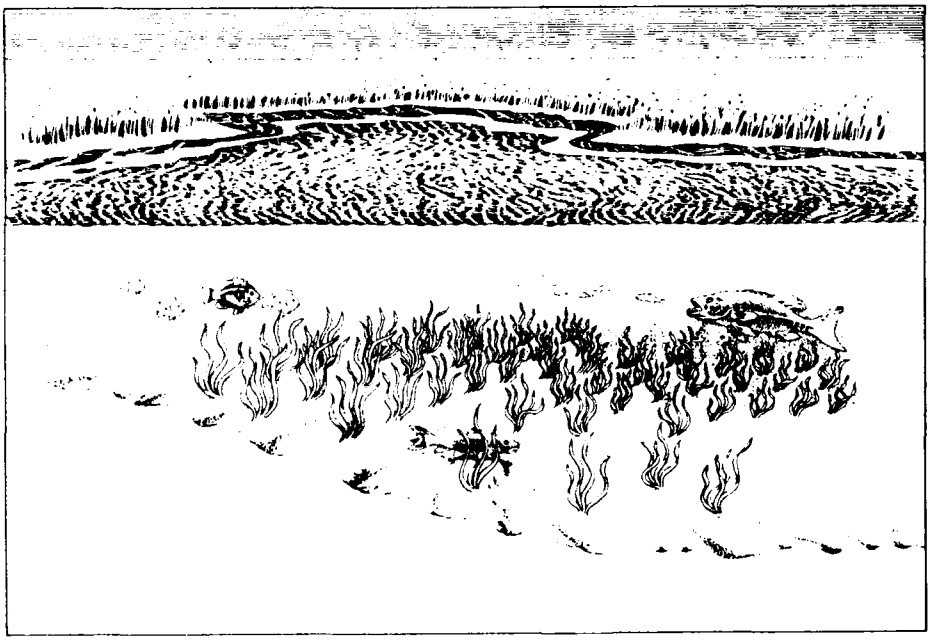
To supplement the efficacy determinations of the insect biocontrols, laboratory and greenhouse investigations of the temperature tolerances of these biocontrol agents will be made. These data are essential as background information for selecting release techniques that will ensure the establishment of these species.

Plant competition

Native aquatic species provide preferred food for waterfowl and favorable habitat for fish and invertebrates. Low-growing native species will be established within aquatic plant beds to determine if these plants can outcompete certain weedy species. Test demonstrations will include such techniques as selective chemical treatment to favor certain species or the use of barriers to control undesirable species, followed by removal of the barrier and subsequent planting of the same area with desirable plants. Initial field tests will be conducted in the ponds at the Murphy Hill site. The overall objective will be to develop multiple control techniques that will allow native beneficial plants to outcompete or suppress nonnative weeds (Figure 20).



a. Population of an introduced weedy species, *Myriophyllum spicatum.* Excessive growth forms a dense mat at the water surface, inhibiting gas exchange and the flow of water—conditions that provide poor habitat for aquatic life



b. Population of a native, nonweedy species. Lower growth profile allows for gas exchange, free exchange of water, and support for aquatic organisms—conditions that provide good habitat for aquatic life

Figure 20. Comparison of growth forms of introduced and native aquatic plant species

Convective hydraulic circulation

The shallow littoral zone of a reservoir heats and cools more rapidly than open-water areas. Further, the presence of aquatic vegetation contributes significantly to the development of thermal gradients. Thermal gradients cause changes in density gradients, thereby promoting convective hydraulic circulation. These circulation patterns influence the transport of herbicides and, thus, treatment effectiveness. Data from this study will also be used to explain changes in water quality as influenced by hydraulic circulation and dense aquatic vegetation.

Details of the applied research area of the JAGP are provided in Appendix G, in the summary work plans titled Temperature Range Testing of Insects for Hydrilla Biocontrol, Temperature Range Testing of *Mycoleptodiscus terrestris*, Evaluation of Biocontrol Agents for Hydrilla, Evaluation of Biocontrol Pathogen for Eurasian Watermilfoil, Plant Competition, and Convective Hydraulic Circulation.

Project Management

The joint project planning and management activities require the integration of the various investigations and surveys with the routine operational aquatic plant control program. Since major portions of this project involve advertising for bids, outside contracting, and monitoring of contracts, continual close staff coordination will be necessary, both within and between agencies and public interest groups.

Interrelationships

The JAGP has been planned to take advantage of multiple-objective opportunities. The project plan considers and builds on TVA's existing control program and technical expertise to achieve improved effectiveness of currently available operational techniques. In addition, databases and evaluations are designed to be applicable to multiple components of the project. In effect, these parts of the project will be used to identify and quantify the interrelated responses of important biological communities and the physical and chemical properties of the aquatic ecosystem, so that a fully integrated total aquatic plant management effort is implemented in Guntersville Reservoir.

The individual components of the project have been planned such that efficiencies will be gained through concurrent data acquisition and/or shared data. As an example, mechanical harvesters are being used not only for operational controls (Appendix E), but are simultaneously providing plant biomass samples for evaluation of grass carp feeding effects (Appendix D) as well as input to simulation modeling (Appendix F). Mechanically harvested material will be sorted as part of the fisheries evaluations (Appendix D) to

determine the numbers, types, and age of fish removed during the harvesting operations. In addition, mechanical harvesters are being used to cut boat lanes for access and to provide fisheries enhancement through the creation of more edge habitat (Appendix F). Each component of the project is periodically examined to ensure that it not only contributes to overall project objectives but also identifies data, products, or results that can contribute to other components, thereby minimizing duplication.

During the period of the JAGP (1990-1995), several major activities will be conducted that are not only related to each other, but will influence TVA's future aquatic plant management program. Figure 21 shows these major activities, their relationships, and how the technology and data resulting from these activities provide a basis for the development of improved annual operational work plans and field applications. Descriptions of these activities are provided in the following paragraphs; details are given in the appendixes to the report.

Project Management. The management team for the JAGP will ensure that information is provided to the public in a timely and effective manner, and that public input to the project is properly incorporated into the appropriate project activities. The management team will also direct and review all technical elements of the project and provide the administrative management necessary to appropriately and efficiently allocate resources to ensure that the overall project objectives are achieved.

Major Technical Activities. Data from the four major technical areas (Economic Evaluations, Operational Enhancement, Demonstrations, and Applied Research) will be compiled and organized into databases that will also be an important technical resource for the Master Planning process. When the first-generation Master Plan is completed, it will provide a comprehensive basis for development of annual operational work plans. As field applications are conducted under these work plans, additional data and technology needs may become available, and will be incorporated into the organized databases.

Public input will be factored into all aspects of the project, on a continual basis. Once the JAGP is completed in 1995, TVA's aquatic plant management program will change, to comprise the related activities as shown in Figure 22.

APC Management. TVA aquatic plant management will continue to provide the public with information on activities, incorporate public input into the updating of the Master Plan and Supplements thereto, and conduct an overall program that reflects current needs and technologies.

Technical Activities. After conclusion of the JAGP, the TVA will continue to draw upon ongoing research being conducted by the Corps of Engineers, other Federal agencies, universities, and as part of its own research projects. The technology advanced during the conduct of the JAGP will subsequently be incorporated into the future TVA program.

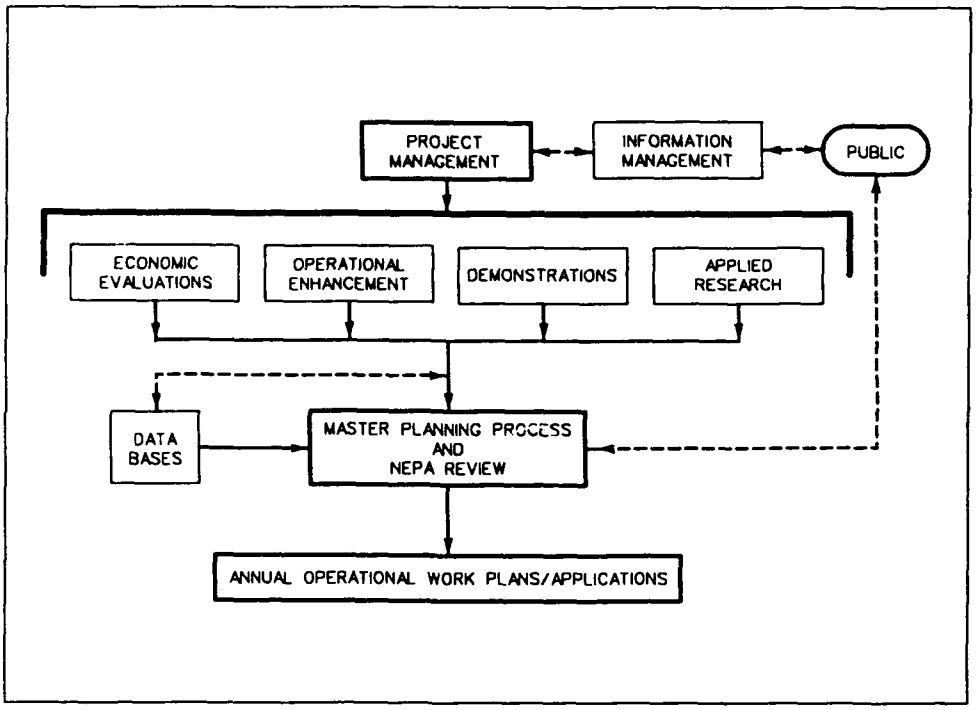


Figure 21. TVA-USACE Joint Agency Guntersville Project activities, 1990-1995

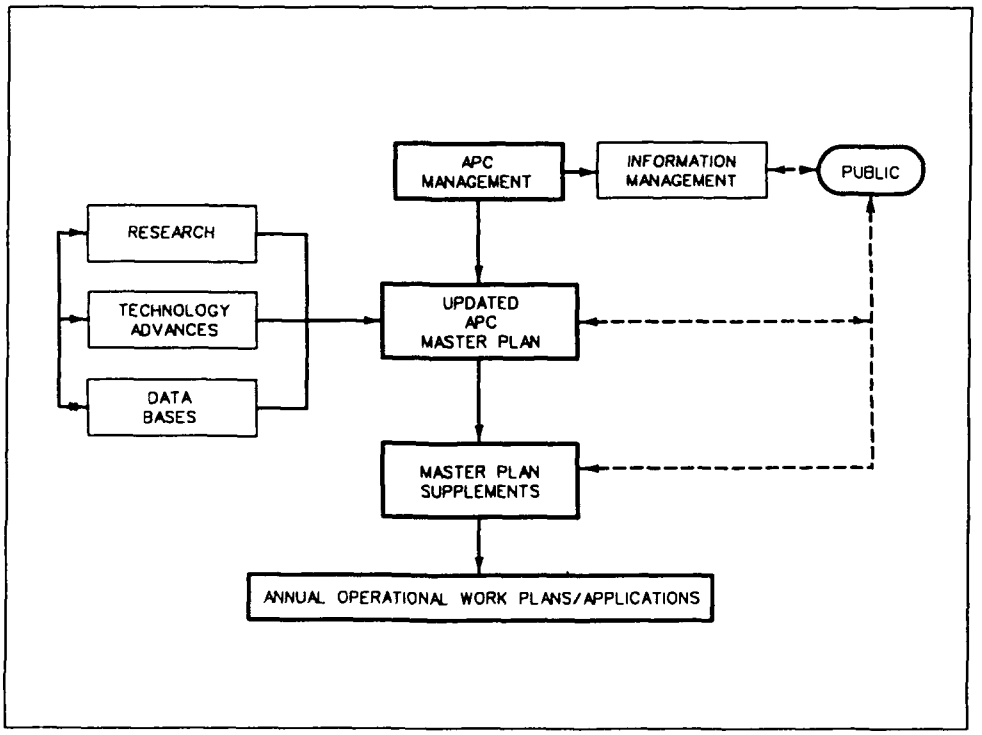


Figure 22. TVA aquatic plant control activities, 1996-future

The databases developed will be utilized and continually updated as new data become available. Collectively, the TVA aquatic plant management program will have current state-of-the-art technologies and capabilities for conducting the needed operations.

Figures 21 and 22 are intended to show not only the relationships between the various activities of the Joint Agency Guntersville Plan, but how the overall project is designed to use the results of these activities to improve TVA's capability to conduct effective, environmentally compatible aquatic plant management operations that reflect the public's identified needs. These figures also represent the difference between the current JAGP activities and the TVA operational mode in the future.

Meetings

Coordination meetings among project leaders and field personnel and contractors are expected to occur on a frequent basis, perhaps as often as weekly during summer months. Periodic meetings with project leaders and primary agency contacts will be held at least twice a year, with the primary agency contacts meeting more frequently.

Since WES is a primary participant in the project, the progress and updates for each project will be presented at the annual APCRP meeting. This will provide for immediate technology transfer and technical coordination. Interagency coordination and technology transfer will also be accomplished through the Federal Aquatic Plant Management Working Group, which is authorized by the Congressionally mandated Interagency Research Coordination Conference. Various professional organizations, such as the Aquatic Plant Management Society, the North American Lake Management Society, the American Fisheries Society, and their regional chapters, will also be used for technology transfer.

Reporting

Several methods for information exchange and technology transfer will be utilized in reporting results from the various technical areas of the Joint Agency Guntersville Project (Figure 23). Specific project areas will provide information and reports on varying schedules, as progress is reached. Generally, the following reporting formats will be used:

- Annual summary updates reporting overall progress for project leaders and primary agency contacts.
- Semiannual reports for contracted tasks, as well as annual reports.
- Review drafts and final versions for each project upon completion.

- Numerous manuscripts for technical refereed journals.

- Annual technical review and reporting to be published as part of the annual proceedings of the Aquatic Plant Control Research Program meeting (Figure 24).

- As a part of the Information/Education task, fact sheets and other general, nontechnical publications are written for distribution to the public sector (Figure 25).

Figure 23. Public information programs keep interested individuals informed about the project and provide a mechanism for reporting results

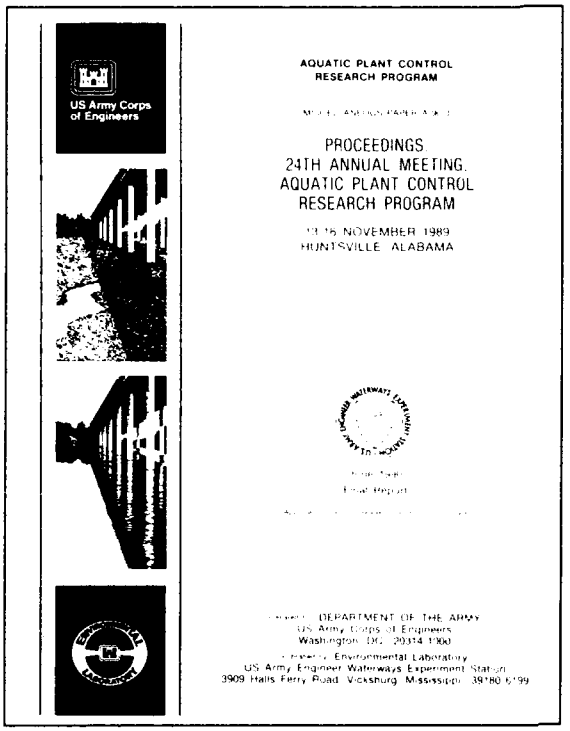


Figure 24. Published proceedings, annual meeting of the Aquatic Plant Control Research Program

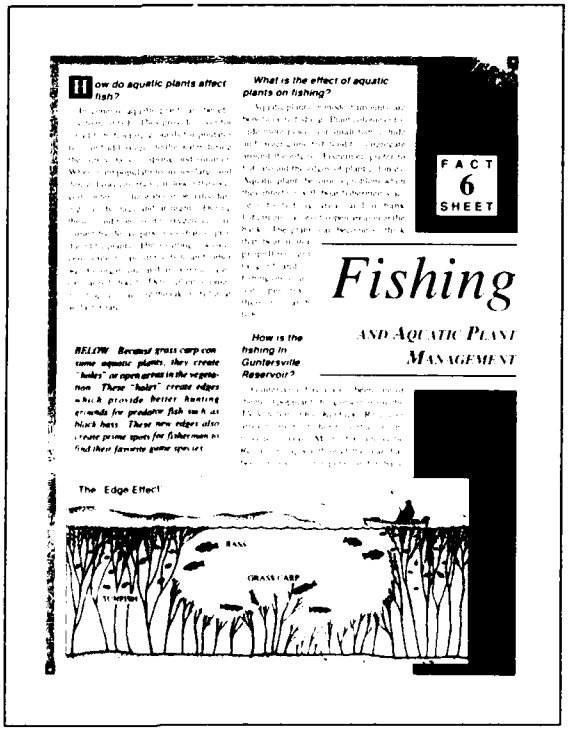


Figure 25. Educational materials such as Fact Sheets are distributed to user groups for information

3 Summary

For some of the control technologies investigated under this project, a period of 2 to 3 years will be required before their effectiveness is evident. The most notable example is the use of biological controls; the hydrellia fly and the watermilfoil pathogen are not projected to be applicable as a control method until 1993 or 1994. Likewise, the use of grass carp is not expected to exert measurable control until summer 1991. The application of plant competition to regulate noxious species is inherently slow because the rate of progress will be dictated by the time required for growth in synchronization with growing seasons.

Other control techniques to be used in the project will result in more rapid changes in the density and abundance of targeted aquatic plants. Harvesting and placement of benthic barriers will result in an immediate change with very discernible boundaries. Chemical (herbicide) controls will exhibit a slightly delayed response of about 2 weeks.

The Joint Agency Plan for Guntersville Reservoir provides a significant opportunity for development of improved aquatic plant management technologies and an efficient mechanism for direct implementation of control technology into an operational program. The joint project involving TVA, WES, and the Nashville District combines a regional resource management agency, a national applied research organization, and an operations-oriented organization into a problem-solving partnership. The respective expertise of each agency is being effectively used to address rapidly emerging water resource problems related to excessive aquatic vegetation, and to optimize the beneficial aspects resulting from properly managed populations of aquatic plants.

Guntersville Reservoir provides an excellent study site. It is a multipurpose reservoir with a long history of diverse aquatic weed problems, a well-documented aquatic plant management program, and extensive biological and water quality databases. It is typical of man-made reservoirs in the region; thus, the findings from this project will ultimately be extended to other similar reservoir systems with significant aquatic plant populations. The relatively large size of Guntersville, with its diverse shoreline uses, provides a wide range of user data important for the economic and recreation assessments.

Several associative benefits from this project to other programs have already been recognized. Supportive databases relating to land management plans, water quality assessments, mapping and aerial photography, and biological data will enhance and integrate with the Joint Agency Guntersville Project. Another notable example is related to the data to be generated in the Master Planning process. Since it will be used later for a scheduled updating of TVA's existing Guntersville Land Management Plan, the geographical database indicating the true reservoir shoreline will have applicability and value to numerous other TVA programs not directly related to aquatic plant control.

In summary, the joint project will provide basic aquatic plant management technology not now available. Basic information from this project will be used to more effectively manage aquatic vegetation in a variety of aquatic habitats encompassing Federal and State reservoir projects throughout the TVA region as well as nationwide.

Appendix A
Planning and Review Process

WORK UNIT TITLE: Project Administration and Planning

NUMBER: 4281-822300-040

PRINCIPAL INVESTIGATOR: A. Leon Bates

PHONE: 205-386-2278

ORGANIZATION: Tennessee Valley Authority

BASIS FOR CONDUCTING WORK:
TVA is the designated lead agency for implementing the Joint Agency Guntersville Project. As lead agency, TVA provides for the overall planning, budgeting, and coordination of the project.

DESCRIPTION OF WORK:
The Joint Agency Guntersville Project was implemented in March 1990 and is projected to extend through September 1994. TVA will initiate and implement personal services contracts and cooperative agreement contracts for appropriate subtasks not conducted by TVA or USACE. TVA will coordinate and direct "onsite" manpower needs and provide logistical support for most projects. Physical facilities for onsite laboratory and field testing will be provided for various projects, and planimetric mapping support is provided through TVA Mapping Services Branch. Assistance is provided to contracting A/E firms in conducting public meetings.

MILESTONES:

Title	Schedule
Prepare and implement project plan	9003
Prepare contracts and cooperative agreement	9003 to 9406
Prepare periodic status reports	9006 to 9409
Submit final report	9412
Assist public meetings	9101
Planimetric base map	9102
Coordination of field activities	9003 to 9409

WORK UNIT TITLE: Aquatic Plant Management Master Plan

NUMBER: 4281-822300-040, Contract No. 80541V

PRINCIPAL INVESTIGATOR: Joe Morrison

PHONE: 615-736-5026

ORGANIZATION: Nashville District, USACE

BASIS FOR CONDUCTING WORK:
Joint Agency Plan for aquatic plant management at Guntersville Reservoir.

DESCRIPTION OF WORK:
Advertise in CBD, select A/E, negotiate contract, and monitor A/E's performance. Manage A/E in preparing a project description of Guntersville Reservoir (GR) and compiling a detailed history of aquatic plants in the Tennessee River Basin. Coordinate and direct A/E in the analyses of economic impacts and management options of aquatic plants in GR. Attend and assist in monitoring public involvement workshops. Direct the preparation of lake use plans, resource management guidelines, and quantitative cost estimates. Coordinate Master Plan revisions and the preparation of an Environmental Assessment (NEPA).

MILESTONES:

Title	Schedule
A/E contract signed	9010
Kickoff meeting and field reconnaissance	9011
Compile background information	9011
Receive GIS base info from TVA	9011
Issue notice for public meetings	9011
Conduct initial public scoping meetings	9012
Responses to public scoping meetings	9102
Compile master plan test	9012
Begin GIS processing	9012
Begin lake use planning	9012
Prepare environmental assessment/FONSI	9104
Submit 75% draft master plan for review	9104
Issue draft master plan for public review	9107
Issue notice for final public meetings	9107
Conduct final public meetings	9108
Submit final master plan camera-ready originals	9110
Submit final GIS documentation	9110
Submit correspondence files	9112
Close out A/E Contract	9112

Appendix B
Information and Education

WORK UNIT TITLE: Information and Education Programs

NUMBER: 4281-822300-050

PRINCIPAL INVESTIGATOR: Anne E. Lyon

PHONE: 615-632-1639

ORGANIZATION: Land Resources, Environmental Education, TVA

BASIS FOR CONDUCTING WORK:
Education and information are key components of the aquatic plant management demonstration on Guntersville Reservoir. A brochure, fact sheets, and other materials will be developed to inform the general public about key components of the Guntersville project and TVA's role in aquatic plant management.

DESCRIPTION OF WORK:
A series of 12 one-page fact sheets, which address topics, such as grass carp, mechanical harvesting, biocontrols, drawdowns, and other pertinent aquatic plant management topics, will be completed. A hydrilla poster suitable for outdoor use will be prepared to encourage boaters to remove aquatic plant fragments from their boats and trailers. Short videos on key elements of the research and a series of slides depicting plant management strategies will be developed. Other proposed activities include a free-standing exhibit, an activities manual for schools, a newletter highlighting results of the demonstration, and other education products.

MILESTONES:

Title	Schedule
Fact sheet series	9103
Short videos	9106 to 9410
Poster	9104
Slide set	9011
Booklet	9111
Brochure	9007
Project video	9010
Project updates	9010 to 9410

Appendix C
Economic/Recreation Evaluations

WORK UNIT TITLE: Economic Valuation of Aquatic Plant Control

NUMBER: 32729

PRINCIPAL INVESTIGATOR: Jim Henderson

PHONE: 601-634-3305

ORGANIZATION: Waterways Experiment Station

BASIS FOR CONDUCTING WORK:
There exists no valuation method for comparing the costs and benefits of alternative technologies and/or strategies for all the benefits derived from aquatic plant control (APC) programs. Additionally, impacts of problem-level aquatic plant infestation (e.g., land use changes) are not well documented. While benefits to project purposes such as navigation and flood control are fairly well understood, no method exists to determine the value to recreation and other activities resulting from APC efforts. The objective for conducting this work is to develop and incorporate economic valuation techniques into the implementation and assessment of aquatic plant control programs.

DESCRIPTION OF WORK:
Conduct a literature review of natural resource valuation and APC work to identify valuation methods and determine the critical attributes of APC efforts. Identify the changes and impacts resulting from aquatic plants and control efforts, through surveys of users (e.g., homeowners and recreation users) at Guntersville Reservoir. Market and nonmarket valuation methods will be evaluated and adapted for use at Guntersville Reservoir. The APC-adapted valuation methods will be field tested at Guntersville Reservoir and potential USACE projects. Documentation on USACE guidance for valuation of APC will be developed.

MILESTONES:

Title	Schedule
Literature review completed	9005
Literature review results and Guntersville Reservoir valuation of APC	9011
Valuation methods for APC, APCRP annual	9011
Report on impacts of aquatic plant control	9103
Report on valuation methods for APC	9108
Land value study results and development of USACE guidance - lands, APCRP annual	9111
Recreation value study results and development of USACE guidance - recreation, APCRP annual	9211
Report on Lake Guntersville field studies	9306
Development of recreation factors for economic input-output model, APCRP annual	9311

Title	Schedule
Draft guidance documentation on valuation of APC	9402
Guidance for valuation of APC, APCRP annual	9411

WORK UNIT TITLE: Land Value - Economic Evaluations

NUMBER: 4281-822300-048, 7545

PRINCIPAL INVESTIGATOR: George R. DeVeny

PHONE: 615-632-8095

ORGANIZATION: Tennessee Valley Authority

BASIS FOR CONDUCTING WORK:
Measurement of the impact of aquatic plant infestation on residential land values and other economic activities on Guntersville Reservoir will be used to provide guidance for the management of aquatic plants on Guntersville Reservoir. It will also have implications for the future direction of TVA and the CE aquatic plant management efforts. Finally, NEPA documentation requires the assessment of current residential land values and evaluation of the effect on values from aquatic plant control actions. This activity will seek to determine past and current land values for selected developments around the reservoir, determine the past and current rate of lake-oriented housing construction, characterize the selected developments in terms of factors affecting values, measure past and current aquatic plant infestation, analyze the data to develop a quantitative relationship between land values and plant infestation, and, if a relationship is found, estimate the effect on current public revenues in the lake area.

DESCRIPTION OF WORK:
Select consultant and develop specific research objectives, study plan, and data collection procedures. Select sample, collect assessed value and ownership information from courthouse records, and enter into database. Field data collection to characterize the sample in terms of such things as land/water relationship, water access, water view, occupancy type, quality of dwelling and surrounding area, etc. Enter into database. Measure weed infestation impacting sample using aerial photography. Analyze and interpret data to estimate the effect of aquatic plant infestation on land values and housing construction, and convert that to an estimate of property tax revenues. Prepare report. Over the project period, monitor changes in land values and housing development. Revise and extend report as appropriate and use the results to develop NEPA documentation.

MILESTONES:

Title	Schedule
Study plan and procedures, coordination	9003 to 9011
Land value data collection	9006 to 9112
Land characterization data collection	9006 to 9112
Aquatic plant infestation data collection	9006 to 9112

Title	Schedule
Data analysis, modeling, impact estimates, report preparation	9110 to 9210
Monitoring, project participation	9209 to 9409

WORK UNIT TITLE: Recreation - Economic Evaluations

NUMBER: 4281-822300-048

PRINCIPAL INVESTIGATOR: Robert A. Marker

PHONE: 615-632-1775

ORGANIZATION: Tennessee Valley Authority

BASIS FOR CONDUCTING WORK:
Measurement of the value of aquatic plant control and assessment of the impact of aquatic plants on reservoir recreation use can provide useful guidance for the management of Guntersville Reservoir and the future direction of TVA's aquatic plant management efforts. NEPA documentation requires the assessment of current reservoir use patterns and evaluation of the effect on use as a result of aquatic plant control actions. The Recreation - Economic Evaluations activity will seek to determine the current use characteristics; public perception of current conditions; preferred aquatic plant levels and preferred control control methods; effect of aquatic plants on recreation users; willingness to pay for control; value of recreational use benefits; and economic impact of recreational use in the local region.

DESCRIPTION OF WORK:
Develop specific research objectives, study plan, and procedures. Write requests for proposals to address components of the project that must be handled by a consultant. Inventory public, commercial, and private recreation facility development. Assess use patterns and develop annual recreation use estimates. Design, field test, and print survey instruments (e.g., mail questionnaires, onsite interviews, and telephone surveys) which will address characteristics of current use, public perceptions, impacts of aquatic plants, user benefits, and willingness to pay for control (CVM). Conduct field implementation of survey instruments, follow-up, data entry, and compilation. Analyze and interpret data. Generate estimates of user benefits, willingness to pay for control, and profile of recreational use. Link recreational use and expenditures to local economic impacts through input-output model. Measure changes in economic indicators in response to changing use and expenditures. Over the project period, monitor changes in recreation facility development, use patterns, and use levels that may be attributable to changes in aquatic plant conditions. Analysis of trend indicators and time series surveys are possible approaches.

MILESTONES:

Title	Schedule
Study plan and procedures, coordination	9003 to 9009
Baseline data collection on use and facilities	9003 to 9010

Title	Schedule
Survey instrument and CVM development, sampling design	9003 to 9009
Field implementation, data collection, entry, technical advisory panel	9010 to 9109
Data analysis, modeling estimation of benefits, control valuation	9010 to 9109
CVM surveys	9009 to 9209
Draft comprehensive report	9110 to 9206
Final report	9209

Appendix D
Database Development and Environmental Evaluations

WORK UNIT TITLE: Database Development and Implementation

NUMBER: 4281-822300-040

PRINCIPAL INVESTIGATOR: Alan W. Voss

PHONE: 615-751-5425

ORGANIZATION: Tennessee Valley Authority

BASIS FOR CONDUCTING WORK:
Valuable data components, important to an understanding of the aquatic plant history and impacts on Guntersville Reservoir, currently reside in various, independently derived hardcopy formats. In addition, new data that describe current conditions on the reservoir will be collected during the joint project. The database activity will assemble and digitally capture key elements of existing and new data. This will ensure compatibility of all pertinent data elements through reference to accurate geographic locations and to a common shoreline. This activity will facilitate analyses of the historical and potential future growth of aquatic plants on the reservoir, interrelationships among natural and cultural resource conditions, and potential environmental and economic impacts.

DESCRIPTION OF WORK:
Shoreline delineation will map the current shoreline as shown on near-full-pool aerial photographs. The shoreline will be transferred to the new database and will become the shoreline on the project's selected common base map. Aquatic plant survey mapping will transfer aquatic plant classifications from the 1989 aerial photographs to the common base map. Database design will define the data structure, data capture specifications and procedures, query and analysis capabilities, and graphic and tabular report formats based on project requirements. This step will also include development of criteria for incorporation of other program data, such as historical aquatic plant locations, historical land use and land cover, nonpoint source inventories, water quality data, and other pertinent data, such as soils, geology, and economic values. Upon completion of the database design, costs for digital data capture and analysis products will be reviewed. A digital database consisting of both mapped and descriptive attribute data will be developed. This will include entering the new reservoir shoreline, the current aquatic plant locations, and other field data into the system; integrating existing digital navigation chart data into the database; and adjusting selected land management planning project data to fit the new shoreline. The analysis of the historical and potential future growth of aquatic plants on the reservoir, interrelationships among natural and cultural resource conditions, and potential environmental and economic impacts will be conducted. Maps and tabular reports that show existing data themes, analyses results, and proposed actions will be provided.

MILESTONES:

Title	Schedule
Shoreline delineation	9010
Aquatic plant survey mapping	9011
Database design	9012
Digital data capture	9010 to 9209
Analyses products	9010 to 9209

WORK UNIT TITLE: Aquatic Macrophyte Evaluations

NUMBER: 4281-822300-044

PRINCIPAL INVESTIGATOR: David H. Webb

PHONE: 205-386-3653

ORGANIZATION: Tennessee Valley Authority

BASIS FOR CONDUCTING WORK:
Stocking of grass carp is expected to result in significant reductions in aquatic macrophytes. Changes in coverage and biomass of aquatic vegetation, rates of decline, and a determination of the relative order of plant species reduction are needed to evaluate the efficacy of grass carp for aquatic plant management. Since reductions in aquatic vegetation impact the structure of other biological communities, such as fish and waterfowl, water quality, and socioeconomic conditions in the reservoir area, aquatic macrophyte data also are needed to evaluate these aspects of the Guntersville Reservoir project and to validate computer simulation models.

DESCRIPTION OF WORK:
Aerial photography - An aerial overflight will be conducted during midsummer (August) for three embayments (North Sauty Creek, Mud Creek, and Crow Creek) to obtain large-scale color photography (1 in. = 600 ft). These embayments contain wildlife management areas or refuges. Ground truthing will be required as well as photointerpretation on overlays attached to photographic prints. Ground truthing and photointerpretation will be conducted for the entire reservoir for aerial photography obtained in late September to October to assess TVA's aquatic plant management program. Macrophyte coverage data from the photographic prints will be provided for incorporation into TVA's Geographic Information System in Chattanooga, TN.

Biomass sampling/life history - Hydrilla and Eurasian watermilfoil colonies will be sampled for biomass (standing crop) during several months to determine growth curves and peak standing crop. Three or more sampling stations for each species will be selected and sampled with the CEWES biomass sampler and/or a mechanical harvester. Standing crop of annual species (naiads, muskgrass, narrow-leaved pondweeds) will be sampled during summer months at selected sites. Wet weights for all biomass samples will be determined after spinning in a washer.

Hydrilla tuber density will be determined at selected sites by use of benthic sampling equipment during winter months.

MILESTONES:

Title	Schedule
Aerial Photography	
Conduct ground truthing	9008 to 9010
Conduct aerial overflight	9008
Complete photointerpretation	9009 to 9102
Conduct ground truthing	9108 to 9110
Conduct aerial overflight	9108
Complete photointerpretation	9109 to 9202
Conduct ground truthing	9208 to 9210
Conduct aerial overflight	9208
Complete photointerpretation	9209 to 9302
Conduct ground truthing	9308 to 9310
Conduct aerial overflight	9308
Complete photointerpretation	9309 to 9402
Conduct ground truthing	9408 to 9410
Conduct aerial overflight	9408
Complete photointerpretation	9409 to 9502
Biomass Sampling/Life History	
Biomass sampling	9004 to 9012
Hydrilla tuber density	9102
Biomass sampling	9102
Biomass sampling	9104 to 9111
Biomass sampling	9206 to 9210
Biomass sampling	9306 to 9310
Biomass sampling	9406 to 9410
Reporting	
Interim report	9104
Interim report	9204
Interim report	9304
Final report	9504

WORK UNIT TITLE: Monitoring Water Quality Impacts

NUMBER: 4281-822300-049

PRINCIPAL INVESTIGATOR: Joseph P. Fehring, Wayne L. Poppe

PHONE: 615-751-7308 (Fehring)
615-751-7333 (Poppe)

ORGANIZATION: Tennessee Valley Authority

BASIS FOR CONDUCTING WORK:
To determine effects of changes in aquatic plant coverage on water quality conditions.

DESCRIPTION OF WORK:
During the course of the project, various water quality variables will be monitored to determine the impact on water quality conditions. Standard monitoring will be conducted in the Nickajack and Guntersville Reservoir forebays and the transition zone of Guntersville Reservoir. Site-specific, intense monitoring will be conducted in areas that serve as experimental units for other portions of this project. This monitoring is designed to examine cause-and-effect conditions, whereas the standard monitoring is designed to provide trend information for the entire reservoir. It is anticipated that the site-specific monitoring will be modified throughout the course of the project to accommodate the needs of the specialized investigations that are being conducted.

MILESTONES:

Title	Schedule
Begin first year water quality monitoring	9004
Complete first year water quality monitoring	9009
Draft of first year interim report	9101
Begin second year water quality monitoring	9104
Complete second year water quality monitoring	9109
Draft of second year interim report	9201
Begin third year water quality monitoring	9204
Complete third year water quality monitoring	9209
Draft of third year interim report	9301

Title	Schedule
Begin fourth year water quality monitoring	9304
Complete fourth year water quality monitoring	9309
Draft of fourth year interim report	9401
Begin fifth year water quality monitoring	9404
Complete fifth year water quality monitoring	9409
Draft of final report	9501

WORK UNIT TITLE: Fisheries Evaluations

NUMBER: 4281-822300-041

PRINCIPAL INVESTIGATOR: William B. Wrenn

PHONE: 205-386-3656

ORGANIZATION: TVA

BASIS FOR CONDUCTING WORK:
To determine effects of changes in aquatic macrophyte coverage on selected aquatic biota with emphasis on the sport fishery.

DESCRIPTION OF WORK:
Fisheries assessments will include the following components: A creel census survey will compare angler effort, harvest, and economic information before and after macrophyte control. Fish health assessment survey will include age and growth, food habits, a comprehensive condition factor index and population dynamics for largemouth bass, crappie, and bluegill. Five rotenone surveys will be conducted during August/September. Popnet sampling will be utilized in vegetated areas in conjunction with rotenone surveys. Chlorophyll and dissolved oxygen measurements will be taken at popnet stations during critical hours and at various stages of plant growth. Hydroacoustic surveys will be conducted during summer and fall to obtain estimates of fish density in pelagic zones; mobile 120-kHz surveys with midwater trawl ground-truthing will be done in upper, middle, and lower reservoir areas. Ponar sampling (benthos) at popnet stations will be conducted. Light trap sampling to evaluate potential reproduction of white amur will be conducted each spring. An assessment of mechanical macrophyte harvesting on fish mortality will be conducted during late summer.

MILESTONES:

Title	Schedule
Creel census—complete data acquisition (year 1)	9011
Creel census—sensitivity analysis	9101
Creel census--continuation (Feb.-Nov.)	9409
Begin fish health assessment	9004
Fish health assessment interim report	9103
Complete fish health assessment	9405
Begin rotenone, popnet, and benthos surveys	9008
Complete rotenone, popnet, and benthos surveys	9408
Begin chlorophyll/DO surveys	9006
Complete chlorophyll/DO surveys	9409
Begin hydroacoustics	9006

Title	Schedule
Complete hydroacoustics	9408
Begin light trap sampling	9006
Complete light trap sampling	9407
Data Systems component (analysis for final report)	9409

WORK UNIT TITLE: Waterfowl and Wetlands Wildlife and Threatened and Endangered Species Evaluations

NUMBER: 4281-822300-047

PRINCIPAL INVESTIGATOR: J. Ralph Jordan

PHONE: 615-632-1604

ORGANIZATION: TVA

BASIS FOR CONDUCTING WORK:
To fulfill monitoring requirements for waterfowl and wetlands wildlife and threatened and endangered species as specified in the Grass Carp Stocking Final Environmental Assessment. Monitoring activities will enable TVA to assess the nature and significance of wildlife-related impacts that may result from the demonstration project.

DESCRIPTION OF WORK:
Waterfowl and wetland wildlife species numbers and location will be recorded for six aquatic plant management units from biweekly fixed-wing aerial surveys conducted from November through March. Monthly helicopter surveys will be conducted on three aquatic plant management units from June through September. Nest productivity of great blue herons will be monitored from observations conducted 1 day per week from March through May at the Bellefonte nesting colony site. Population censuses will be conducted at the Bellefonte and Roseberry Creek nesting colony sites. Weekly fixed-wing aerial surveys of the aquatic plant management units will be conducted from mid-April through May to identify primary feeding sites during the brood-rearing period when demand for fish is highest. A winter waterfowl ecology/aquatic plant relationships study, designed to examine the winter ecology of gadwall and ring-necked ducks on Guntersville Reservoir, will be conducted. Gray bat numbers will be censused at Hambricks and Blowing Wind (Sauta) Caves. Foraging ecology of gray bats on Guntersville Reservoir study will be studied.

MILESTONES:

Title	Schedule
Waterfowl population monitoring	8911 thru 9409
Wading bird population monitoring	9003 thru 9406
Winter waterfowl ecology/aquatic plant relationships research	9010 thru 9409
Gray bat population monitoring	9005 thru 9409
Gray bat foraging ecology research	9010 thru 9409

WORK UNIT TITLE: Phytoplankton Evaluations

NUMBER: 4281-822300-051

PRINCIPAL INVESTIGATOR: Wayne Poppe

PHONE: 615-751-7333

ORGANIZATION: Tennessee Valley Authority

BASIS FOR CONDUCTING WORK:
To measure changes in phytoplankton populations as influenced by physical parameters and water quality conditions.

DESCRIPTION OF WORK:
The stocking of grass carp in Guntersville Reservoir involves the monitoring of water quality impacts and associated changes in the phytoplankton community. Weather-induced (i.e., low flows, high nutrient fluxes) pulses in algal populations are common and are known as algae blooms; thus, monitoring programs are necessary to quantify these changes and identify the stimulus. Overbank areas within the shallow littoral zone as well as main channel and forebay sites along the lower two-thirds of Guntersville Reservoir will be monitored. Routine plankton sampling will be made at five locations to quantify plankton populations.

MILESTONES:

Title	Schedule
Field sampling, first year	9006 to 9010
Interim report	9104
Field sampling, second year	9104 to 9110
Interim report	9204
Field Sampling, third year	9204 to 9210
Final report	9304

Appendix E
Operational Enhancements

WORK UNIT TITLE: Mechanical Control - Aquatic Plant Harvester

NUMBER: 4281-822300-045

PRINCIPAL INVESTIGATOR: George P. Chambers

PHONE: 205-386-2086

ORGANIZATION: Tennessee Valley Authority

BASIS FOR CONDUCTING WORK:
The use of a mechanical harvester for the control of aquatic macrophytes in the TVA reservoir system has not been demonstrated and evaluated on an operational basis. This activity will assist other projects with required data acquisition and permit a field operational evaluation of the harvester(s) on a large hydroelectric reservoir.

DESCRIPTION OF WORK:
Designated transects will be sampled with harvester for biomass sampling of hydrilla and watermilfoil, and for fish biomass affected by harvester operations. Data will be acquired to verify the white amur stocking model and the mechanical harvester model. Aquatic plant control operations demonstration and evaluation on hydrilla, watermilfoil, algae, and other macrophytes in selected areas, such as potable water intake buffer zones and priority areas selected in high-use zones, will be conducted. Various boat lanes patterns will be cut and evaluated for enhancement of fisheries.

MILESTONES:

Title	Schedule
Biomass sampling for monitoring macrophytes and fish	9006 to 9206
Data collection for verification of amur stocking model and HARVEST model	9006 to 9110
Plant control operational demonstration on hydrilla, watermilfoil, algae, and other aquatic macrophytes	9006 to 9110
Boat lane pattern demonstration and evaluation	9006 to 9110
Final report	9112

WORK UNIT TITLE: Chemical Control

NUMBER: 4281-822300-046

PRINCIPAL INVESTIGATOR: Earl R. Burns

PHONE: 205-386-3650

ORGANIZATION: Tennessee Valley Authority

BASIS FOR CONDUCTING WORK:
Chemical control is one of the most valuable techniques available to the aquatic plant manager for controlling unwanted aquatic vegetation. When used properly, herbicides provide safe, effective, site-specific, and species-selective weed control. The number of herbicides approved for use in aquatic sites is limited. Information is needed on how to more effectively utilize these herbicides to provide control under conditions of moderate and high water exchange, to provide better control of marginally susceptible species, and how to apply herbicides more efficiently. In addition, data are needed to support registration of new uses of herbicides and plant growth regulators which have potential for operational aquatic plant management programs. Questions are still raised, primarily by the public sector, concerning the safety of aquatic herbicides to the public and the environment. Additional scientific data on dissipation rates, fate of herbicides and metabolites, residue accumulations, and effects on fish and fisheries are needed to support the thesis that herbicides can be used in an operational program without creating adverse effects to man or the environment.

DESCRIPTION OF WORK:
Municipal water supplies will be monitored for aquatic herbicide residues. Municipal water treatment plants on Guntersville Reservoir will be sampled at monthly intervals, beginning 2 weeks before aquatic herbicide applications are initiated and continuing through the treatment season. Potable water samples will be analyzed for all herbicides used in the aquatic weed control program. In addition, special monitoring studies will be conducted when major herbicide applications are made in the vicinity of municipal water intakes. Sampling sequence for these studies would include pretreatment, and 1, 4, 8, 16, 24, 48, and 96 hr posttreatment. Sediment will also be analyzed for herbicide and/or metabolite residues.

Selected fish species will be confined in enclosures in priority treatment areas before treatment and evaluated for mortality and herbicide residues following routine herbicide application. Mortality evaluations will be made 24, 48, and 96 hr after treatment and compared to a control. Herbicide residue analyses will be made on edible fish.

Several sites in shoreline priority areas will be selected for monitoring prior to and after herbicide applications, to document time required for herbicide residues to dissipate to or below potable water tolerances. Sites will be selected that are representative of priority treatment areas on

Guntersville Reservoir with respect to depth, water quality, and water flow conditions.

Concentrations of dye applied alone and in combination with herbicides will be monitored following application and compared to herbicide residue analyses. If dye dissipation proves to be a reliable predictor of herbicide dissipation, dye tests may become valuable in operational programs as a quick, reliable way to determine necessary waiting periods after treatment for swimming, fishing, and domestic water use.

Lyngbya is a filamentous blue-green algae that produces large unsightly mats on the water surface and imparts an off-flavor to fish. Lyngbya is becoming more prevalent on Guntersville and other TVA reservoirs, and current control operations are ineffective. The proposed demonstration would utilize multiple applications of copper-based and other algicides to suppress or prevent mat formation of Lyngbya. Further investigations will entail determining nursery areas, distributions, and phenology.

New herbicides, herbicide formulations, and growth regulators will be evaluated and demonstrated. Triclopyr (Renovate), bensulfuron methyl (Mariner), and a new granular formulation of endothall (Aquathol K) are some of the herbicides to be evaluated for submersed aquatic weed control. Efficacy and residue data will be obtained to support EPA registration requirements. Herbicides will also be evaluated on emergent species, such as alligatorweed and cutgrass.

To be effective and safe, herbicides must be applied at the correct rate. In addition, the efficiency of herbicidal control programs is influenced by the time required to make proper application. In this activity a commercial computerized herbicide application system, which automatically adjusts application rates based on boat speed, water depth, and swath width, will be evaluated for effectiveness and economy.

Aquatic plants are more difficult to control in some priority treatment areas than in other areas on Guntersville Reservoir. This difficulty has been attributed to plant species, water depth, and rate of water exchange. In this activity, herbicide concentration/exposure time studies will be conducted in the TVA hydraulic flume facility located in Browns Ferry, AL. Various aquatic herbicides (e.g., fluridone endothall, diquat, triclopyr, etc.) will be evaluated against Eurasian watermilfoil and hydrilla. The herbicide concentrations and exposure times selected for these studies will be based on results from small-scale evaluations being conducted at the WES.

Dyes will be used in the Guntersville treatment sites to predict water exchange rates and herbicide dissipation. Using these data, and data from the concentration/exposure time studies, a herbicide control program will be implemented and evaluated.

Experiments will be conducted to see if plant growth regulators can be used to induce submersed aquatic species, such as milfoil and hydrilla, to produce short, compact plants that do not, or are slow to, reach the water surface.

If the growth habit of these species can be manipulated by the use of environmentally acceptable chemicals, the disadvantages of excessive plant growth can be minimized and the advantages of vegetation for fisheries could be maintained. Both laboratory and pond studies will be conducted. Information to be collected includes efficacy and residue data.

MILESTONES:

Title	Schedule
Herbicide residue and toxicity monitoring	9005 to 9205
Herbicide/dye dissipation rates	9105 to 9310
Lyngbya control - biology	9010 to 9110
Evaluation of new herbicides	9007 to 9310
Herbicide concentration/exposure time studies	9106 to 9310
Plant growth regulators	9106 to 9310
Herbicide/fish response	9105 to 9210

Appendix F: Demonstrations

WORK UNIT TITLE: Grass Carp Stocking

NUMBER: 4281-822300-040

PRINCIPAL INVESTIGATOR: David H. Webb

PHONE: 205-386-3653

ORGANIZATION: Tennessee Valley Authority

BASIS FOR CONDUCTING WORK:
Stocking rates of grass carp required to obtain desired levels of aquatic plant coverage in large systems with diverse aquatic plant communities have not been developed with a high level of certainty. Guntersville Reservoir was stocked with 100,000 sterile grass carp in 1990. Additional fish may be required to reach aquatic plant management objectives if ongoing monitoring indicates no adverse effects to water quality and other biological communities as a result of the 1990 grass carp stocking.

DESCRIPTION OF WORK:
About 35,000 sterile grass carp would be released into Guntersville Reservoir in 1992. Fish would be purchased from commercial sources, be a minimum of 9 in. in length, and be sterile triploids.

MILESTONES:

Title	Schedule
Release of grass carp	9204 to 9206

WORK UNIT TITLE: Simulation Modeling

NUMBER: 4281-822300-042

PRINCIPAL INVESTIGATOR: Mike Stewart, WES
David Webb, TVA

PHONE: 601-634-2606 (Stewart)
205-386-3653 (Webb)

ORGANIZATION: Tennessee Valley Authority

BASIS FOR CONDUCTING WORK:
Operational management of aquatic plants in Guntersville Reservoir is difficult because of the complexity of ecological and environmental factors that influence aquatic plant growth and control technique effectiveness. A menu-driven, PC-based software system will be developed which links simulation models developed by CEWES that are applicable to aquatic plant management in Guntersville Reservoir. The applicability of the linked software system as an aid to decision-making by aquatic plant managers will be demonstrated.

DESCRIPTION OF WORK:
Hydrilla and Eurasian watermilfoil colonies will be sampled for biomass during 1990, 1991, and 1992 at monthly intervals during the growing season and at least once during each overwintering period. These data will be used to calibrate existing plant growth models (HYDRILLA and MILFOIL) for Guntersville Reservoir conditions. A PC-based, menu-driven software package will be developed which links HYDRILLA and MILFOIL plant growth models and simulation models (HARVEST, AMUR/STOCK, and HERBICIDE) of operational control techniques applicable to Guntersville Reservoir. A portion of the TVA digital environmental database for Guntersville Reservoir will be acquired by WES. Techniques for utilizing the database for supporting initialization of the simulation models and for storing, displaying, and evaluating simulation results will be developed and demonstrated.

MILESTONES:

Title	Schedule
Select plant sampling locations	9004
Status report, FY 90 efforts	9103
Develop linked software package	9109
Status report, FY 91 efforts	9203
Complete plant biomass sampling	9209
Complete demonstration of software packages	9309

WORK UNIT TITLE: White Amur Model Predictions and Monitoring

NUMBER: 740-7

PRINCIPAL INVESTIGATOR: Mike Stewart

PHONE: 601-634-2606

ORGANIZATION: Waterways Experiment Station

BASIS FOR CONDUCTING WORK:
The level of infestation and growth of aquatic plants in Guntersville Reservoir (GR), Alabama, interferes with the intended uses of the reservoir. The Tennessee Valley Authority plans to stock triploid white amur fish in GR for control of the excessive plant growth, and needs technical information and assistance in determining proper stocking rates. The objective is to refine/update the AMUR/STOCK model and to use the model to generate simulation results for different stockings of triploid white amur under the range of plant type and plant density conditions existing in GR.

DESCRIPTION OF WORK:
Field data will be collected to describe overwintering conditions and spring regrowth initiation of hydrilla and Eurasian watermilfoil in selected GR locations infested with these plant species. The AMUR/STOCK simulation model will be modified and calibrated for GR conditions using the field data. Several sets of simulation results will be generated using the AMUR/STOCK model for different stockings of white amur under the range of plant type and plant density conditions present in GR, and the simulation results will be provided to TVA. The PC-based model will be made available to CE Districts and other agencies that have similar aquatic plant problems.

MILESTONES:

Title	Schedule
Initiate field data collection effort	9001
Initiate revisions to AMUR/STOCK model	9002
Initiate model calibration	9005
Complete revisions to model and calibration to GR environmental conditions	9007
Generate/transfer AMUR/STOCK simulation results for GR to TVA	9009

WORK UNIT TITLE: Creation of Boat Lanes for Fishery Enhancement

NUMBER: 4281-822300-041

PRINCIPAL INVESTIGATOR: Jack Killgore

PHONE: 601-634-3397

ORGANIZATION: Waterways Experiment Station

BASIS FOR CONDUCTING WORK:
The purpose of this study is to determine the effects of different boat lane configurations on the fishery of Lake Guntersville. A mechanical harvester will create boat lanes through areas of dense submersed aquatic plants. These lanes should provide boat access and additional fishing areas, but may also be an important fishery habitat in dense, monotypic plant beds. For example, boat lanes can be used by piscivorous fishes where foraging efficiency on small sunfish is enhanced. However, there are currently no guidelines on boat lane configuration to maximize the benefits of this control strategy. It may be advantageous to orient boat lanes parallel to the flow of the water (gravity or wind-driven) to increase hydraulic circulation within the plant bed. This may reduce drastic fluctuations in dissolved oxygen and pH, thus creating more usable fishery habitat within the vegetated area.

DESCRIPTION OF WORK:
Different configurations of boat lanes will be determined based on plant species and density, water quality, site morphology, and fishing potential. A mechanical harvester will cut the lanes in representative areas (cove and main channel border) during June and September. Diel measurements of water quality and fish utilization will be made at each boat lane and control site. Control sites will be located in areas with naturally occurring dense plant beds without well-defined edges. Vertical profiles of water quality (temperature, dissolved oxygen, pH, conductivity, and turbidity) will be measured with a Hydrolab. Fishes will be collected with a boat-mounted electroshocker, identified to species, weighed, and measured. A comparison of fish abundance and water quality will be made between the lanes and control sites using appropriate statistical methods. In cooperation with TVA, angler effort and harvest will be determined by creel surveys to evaluate the fishing potential provided by boat lanes.

MILESTONES:

Title	Schedule
Create boat lanes	9107
Field sampling	9108
Creel census	9109

WORK UNIT TITLE: Application of Benthic Barrier Technology

NUMBER: 32737, 4281-822300-041

PRINCIPAL INVESTIGATOR: John Barko

PHONE: 601-634-3654

ORGANIZATION: Waterways Experiment Station

BASIS FOR CONDUCTING WORK:
Quantitative information on the long-term effectiveness and environmental impacts of benthic barrier applications is lacking. General concerns include changes in the chemistry and biology of sediment underlying barriers under field conditions. Of major interest are possible alterations in sediment chemistry that may influence plant regrowth on treated sites. The objective of this work unit is to provide quantitative information on the effectiveness and environmental impacts of benthic barrier application at Guntersville Reservoir.

DESCRIPTION OF WORK:
Applications of the benthic barrier fabric will be made to control the growth of nuisance submersed aquatic vegetation in Guntersville Reservoir. The treated sites will then be monitored to determine changes occurring in sediment chemistry and biology. At yearly intervals during the treatment period, barriers or portions of barriers will be removed from designated plots. In concert with plant competition studies, certain of these plots will be allowed to revegetate naturally, while others will be planted with desirable plant species, to determine effects of barrier placement on plant regrowth and species composition. Results of this effort, in combination with those obtained at other sites nationwide, will provide an evaluation of the long-term effectiveness of benthic barrier placement.

MILESTONES:

Title	Schedule
Benthic barrier placement	9005
Initiate chemical and biological studies	9008
Status report FY91, APCRP Annual Proceedings	9101
Status report FY92, APCRP Annual Proceedings	9201
Status report FY93, APCRP Annual Proceedings	9301
Complete chemical and biological studies	9309
Status report FY94, APCRP Annual Proceedings	9401
Final report	9409

Appendix G
Applied Research

WORK UNIT TITLE: Temperature Range Testing of Insects for Hydrilla Biocontrol

NUMBER: 4281-822300-043

PRINCIPAL INVESTIGATOR: Al Cofrancesco

PHONE: 601-634-3182

ORGANIZATION: Waterways Experiment Station

BASIS FOR CONDUCTING WORK:
Insect biocontrol agents for hydrilla have been released and evaluated primarily in Florida, and have not yet been used as far north as Guntersville Reservoir. Laboratory and greenhouse investigations of the temperature tolerance of these organisms are needed to determine whether they can survive and prosper in the Guntersville Reservoir area. These studies will provide background information necessary for the selection of release techniques that are optimal for establishment of the insects.

DESCRIPTION OF WORK:
Survival, feeding, and developmental rates of insect biocontrol agents for hydrilla will be measured at temperatures from 5° to 35° C. Initially, techniques for measuring these processes will be developed. Insects will then be reared in environmental growth chambers at specific temperatures; survival, rate of development, and damage will be quantified. Longer term, low-temperature experiments will quantify the survival of all life stages at various periods of exposure to low temperatures. Field observation experiments will be conducted to document the manner in which these organisms respond to changes in temperature.

MILESTONES:

Title	Schedule
Status report at 1990 APCRP annual review	9011
Status report at 1991 APCRP annual review	9111
Status report at 1992 APCRP annual review	9211
Status report TVA	9303
Status report at 1993 APCRP annual review	9311
Final report to TVA	9409
Status report at 1994 APCRP annual review	9411

WORK UNIT TITLE: Temperature Range Testing of *Mycoleptodiscus terrestris*

NUMBER: 4281-822300-043

PRINCIPAL INVESTIGATOR: Al Cofrancesco

PHONE: 601-634-3182

ORGANIZATION: Waterways Experiment Station

BASIS FOR CONDUCTING WORK:
Mycoleptodiscus terrestris, the fungal biocontrol agent for Eurasian watermilfoil that will be evaluated in Guntersville Reservoir, has been tested almost exclusively in the northeastern United States at relatively low water temperatures. Laboratory and greenhouse investigations of the temperature response of this organism are needed to establish upper and lower temperature limits for its effective use. These studies will provide a basis for the selection of optimal times and locations for application of the fungus in Guntersville Reservoir.

DESCRIPTION OF WORK:
The growth of *M. terrestris* (MT) and its impact on Eurasian watermilfoil will be tested at a range of temperatures from 10° to 35° C. First, laboratory experiments will quantify the effect of temperature on growth of MT on standard microbiological media. Greenhouse experiments will then determine the effect on plants of a commercial formulation of MT at several temperatures. Plants from different growth stages (e.g., preflowering, postflowering) will be tested to determine the optimal combination of temperature and growth stage at which to apply MT.

MILESTONES:

Title	Schedule
Status report at 1990 APCRP annual review	9011
Finish evaluating MT growth rates	9108
Status report at 1991 APCRP annual review	9111
Finish evaluating commercial formulation	9112
Final report to TVA	9206
Status report at 1992 APCRP annual review	9211

WORK UNIT TITLE: Evaluation of Biocontrol Agents for Hydrilla

NUMBER: 32734

PRINCIPAL INVESTIGATOR: Al Cofrancesco

PHONE: 601-634-3182

BASIS FOR CONDUCTING WORK:
Excessive growth of hydrilla interferes with multipurpose uses of Guntersville Reservoir. Biological control using insect herbivores has the potential to provide cost-effective, specific control with little or no effect on desirable plant species. The objective is to release and evaluate a complex of insect biocontrol agents for the control of hydrilla in Guntersville Reservoir.

DESCRIPTION OF WORK:
Two insect species that feed on hydrilla, *Hydrellia pakistanae* (HP) and *Hydrellia* n. sp. (HN), will be introduced. Each species will be released over a period of time in several small enclosures until establishment can be determined. After initial establishment is ascertained, quantitative sampling will be accomplished to determine population numbers and the effect on existing hydrilla infestations.

MILESTONES:

Title	Schedule
Initial HP release	9007
APCRP Proceedings - Status report	9101
Begin monitoring HP populations and their effects	9107
Initial HN release	9107
APCRP Proceedings - Status report	9201
Begin monitoring HN populations and their effects	9207
APCRP Proceedings - Status report	9301
Complete monitoring of HP	9307
APCRP Proceedings - Status report	9401
Complete monitoring of HN	9403
Final report	9409

WORK UNIT TITLE: Evaluation of Biocontrol Pathogen for Eurasian Watermilfoil

NUMBER: 32735

PRINCIPAL INVESTIGATOR: Al Cofrancesco

PHONE: 601-634-3182

BASIS FOR CONDUCTING WORK:
Excessive growth of Eurasian watermilfoil interferes with multipurpose uses of Guntersville Reservoir. Biological control using pathogens has the potential to provide cost-effective, specific control with little or no effect on desirable plant species. The objective is to release and evaluate a commercial formulation of a biocontrol pathogen for the control of Eurasian watermilfoil in Guntersville reservoir.

DESCRIPTION OF WORK:
A fungal pathogen of Eurasian watermilfoil, *Mycoleptodiscus terrestris* (MT), will be evaluated for use as a mycoherbicide. Trials with MT will initially be conducted as prescribed by an experimental use permit (EUP). Later trials will be expanded in scale as regulations allow.

MILESTONES:

Title	Schedule
Survey for pathogens at Guntersville	9005
APCRP Proceedings - Status report	9101
Begin MT pond trials, as per EUP	9105
APCRP Proceedings - Status report	9201
Conduct first large-scale applications of formulation	9205
APCRP Proceedings - Status report	9301
Conduct second large-scale applications of formulation	9307
APCRP Proceedings - Status report	9401
Final report	9404

WORK UNIT TITLE: Plant Competition

NUMBER: 32736

PRINCIPAL INVESTIGATOR: Mike Smart

PHONE: 601-634-3718

ORGANIZATION: Waterways Experiment Station

BASIS FOR CONDUCTING WORK:
The prolific growth of weedy species of submersed aquatic plants such as Eurasian watermilfoil and hydrilla results in a serious interference with the navigation, economic, recreational, and aesthetic values of Guntersville Reservoir and other public waters. These weedy species are well adapted for colonizing new and/or disturbed substrates, and their spread depends in large part on the availability of open (nonvegetated) habitats for the initial establishment of shoot fragments. The objective is to develop operational techniques and guidelines which will slow the spread of weedy species by promoting the establishment and persistence of beneficial native, nonweedy species.

DESCRIPTION OF WORK:
Selected sites requiring control will be treated with herbicides to remove weedy vegetation. Additional sites will be covered with benthic barriers following chemical treatment. Competitive, nonweedy species will then be planted in these sites to slow reinvasion by weedy species. Environmental variables affecting the establishment, growth, and persistence of competitive species will be identified in separate (APCRP-funded) studies in experimental pond systems. Information obtained in those pond studies will be applied in Guntersville Reservoir studies to provide field verification of pond findings. Evaluation of competitive exclusion as an aquatic plant management technique will be accomplished by comparing the frequency, extent, and duration of weedy infestations in control and planted areas. Recommendations for using nonweedy vegetation for aquatic plant management in Guntersville Reservoir and other public waters will be developed.

MILESTONES:

Title	Schedule
Identify field sites for experimentation	9005
Chemical treatment of sites	9006
Placement of barriers	9007
Planting of competitive species	9007
Field evaluation	9009
Status report of FY90 work, APCRP Annual Proceedings	9011
Initiate second-generation field experiment	9106

Title	Schedule
Status report of FY91 work, APCRP Annual Proceedings	9111
Initiate field experiment	9206
Status report of FY92 work, APCRP Annual Proceedings	9211
Interim Technical Report	9303
Initiate field experiment	9306
Status report of FY93 work, APCRP Annual Proceedings	9311
Final report	9409

WORK UNIT TITLE: Convective Hydraulic Circulation

NUMBER: 4281-322300-046

PRINCIPAL INVESTIGATOR: John Barko

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ORGANIZATION: Waterways Experiment Station

BASIS FOR CONDUCTING WORK:
On a daily basis, shallow regions of reservoirs typically heat and cool more rapidly than adjacent open-water regions, due partly to differences in mixed volume. The presence of aquatic vegetation in shallow littoral regions contributes significantly to the development of resulting thermal gradients, as foliage near the water surface converts solar irradiance to heat. Thermal gradients give rise to density gradients, thereby promoting convective hydraulic circulation. Implications of daily convective hydraulic circulation are potentially far-reaching, since dissolved constituents including herbicides and nutrients are potentially transported out of the littoral zone into the open water. Data are needed on effects of convective hydraulic circulation on the efficacy of herbicide application in Guntersville Reservoir. In addition, these data will be necessary to evaluate changes in water quality influenced by altered patterns of hydraulic circulation resulting from reductions in the population densities of aquatic macrophytes.

DESCRIPTION OF WORK:
Air and water temperature will be monitored at half-hour intervals at five stations along a transect perpendicular to shore extending through an extensive macrophyte bed. In addition, wind speed and direction will be monitored at 15-min intervals. These data will be used to describe the strength of temperature gradients seasonally, to identify periods of potential convective transport, and ultimately to model convective transport processes in Guntersville Reservoir. Using a fluorescent dye, direct observations of hydraulic exchange will be made at monthly intervals between June and October. The dye will be placed as a uniform cloud at a designated station in the littoral zone. Dye movement will be monitored with a Turner Designs fluorometer. Primary goals in data collection will be to monitor depletion in dye concentration at the point of injection, track the leading edge of the dye cloud, and trace the spatial configuration of the dye cloud over time. Nutrient concentration data collected during the conduct of selected dye studies will be coupled with flow estimates, calculated from dye movement, to initially determine nutrient fluxes into and out of the littoral zone.

MILESTONES:

Title	Schedule
Complete initial installation and testing of equipment	9009
Results of initial data reduction and analysis	9109
Interim draft report	9202
Results of continued reduction and analysis of data	9309
Final draft report	9409